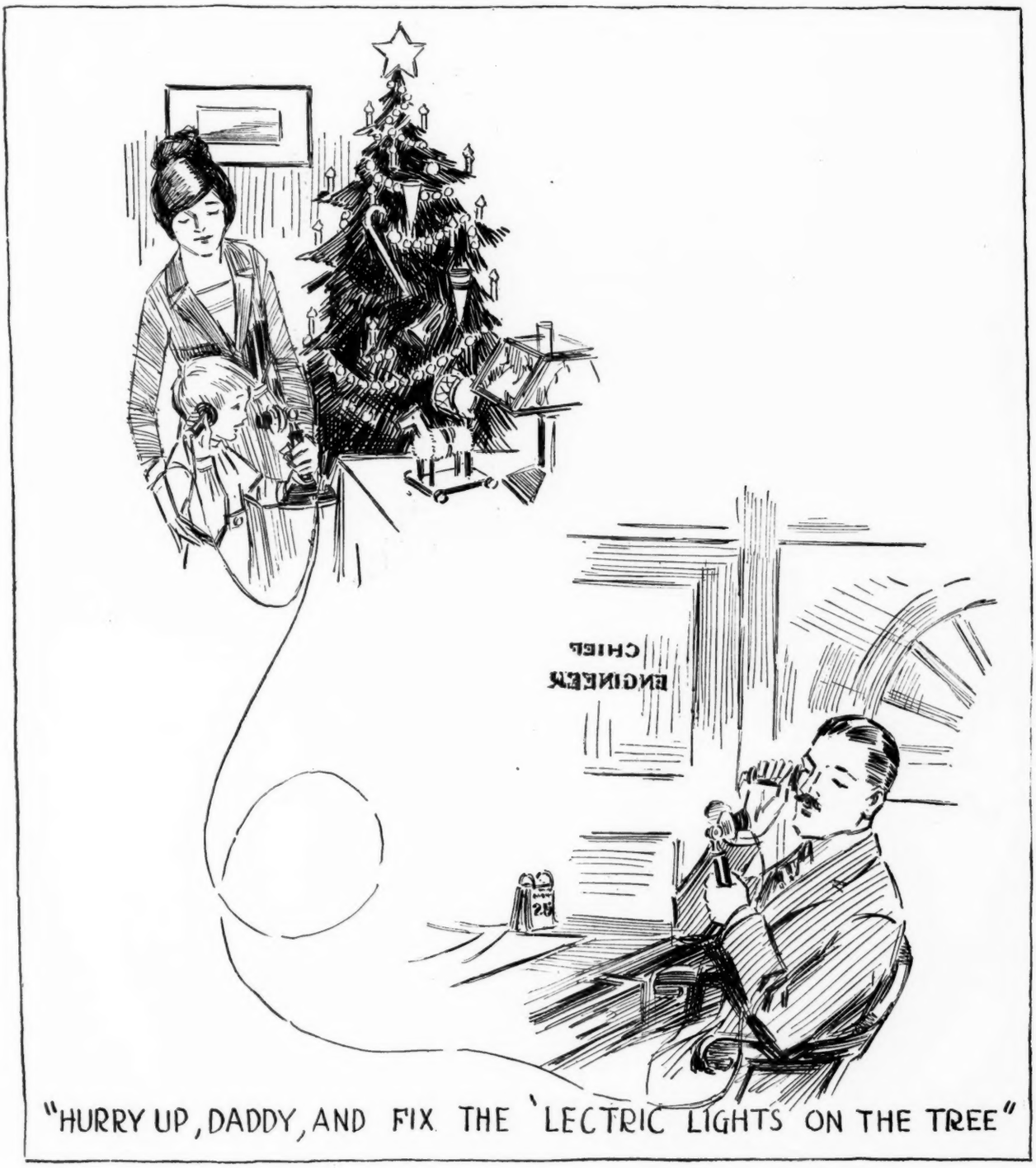
POWER

Volume 52 New York, December 21, 1920 *Number* 25



"HURRY UP, DADDY, AND FIX THE 'LECTRIC LIGHTS ON THE TREE"

New Armour Plant at Kansas City

Modern Boiler Installation, 500-Ton Horizontal Ammonia Compressor and Generating Units, with Mixed-Pressure Turines of the Extraction Type To Give an Approximate Exhaust Steam Balance

AT KANSAS CITY, Kan., the packing plant of Armour & Co. is second only to headquarters at Chicago. It turns out a similar line of widely diversified products and during the war was the plant that made the emergency rations for the Army. This is the condensed food, compressed under 5,000-lb. hydraulic pressure, that made it possible for the "lost battalion" to exist. With this additional demand the capacity of the packing house was taxed to the limit and particularly the power plant, consisting of 8,000 hp. in boilers, Corliss-engine-driven generating units and vertical ammonia compressors, engine-driven. Much of this equipment was old, and the severe service put it in such condition that it was expensive to operate. Continued trouble had been experienced with surface condensers, due to unfavorable water conditions, and the generating capacity was so much below requirements that considerable current had to be purchased.

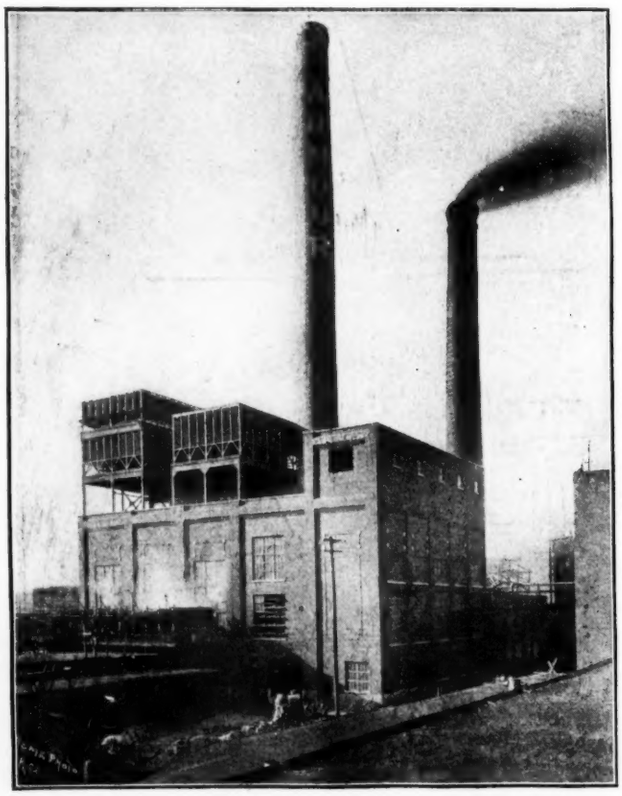


FIG. 1. EXTERIOR VIEW OF THE NEW POWER-HOUSE ADDITION

Shortly before the armistice, plans were drawn up for a new plant, and construction has progressed so that the initial installation will soon be in operation. It is replacing the old original plant known as section No. 1 of the power plant. Two later sections will be allowed to remain and will be operated at moderate capacities in conjunction with the new plant. The latter is to consist eventually of ten 583-hp. water-tube boilers, refrigerating and electric-generating equipment.

As an initial installation four boilers have been placed in service. They operate at 180 lb. pressure and have superheaters with sufficient surface to superheat the steam 50 deg. F. As it is planned to burn

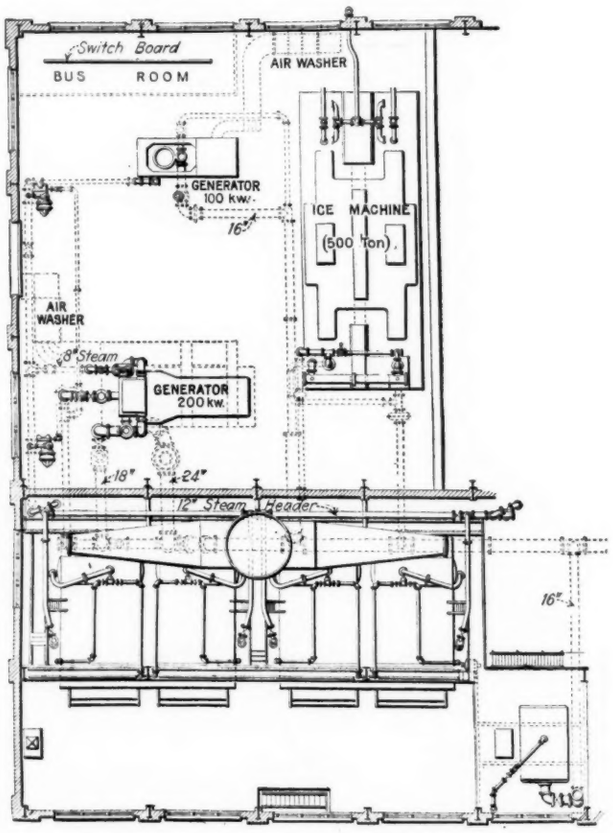


FIG. 2. PLAN OF THE NEW POWER HOUSE

Cherokee slack or Illinois screenings from the Springfield district, chain-grate stokers have been selected. Each has an active grate area of 135 sq.ft., giving a ratio to the steam-making surface of approximately 1 to 43. Thus the grate has ample proportions for the inferior coal to be burned, and with the bottom of the front header 15 ft. above the floor, large furnace volume has been provided. Approximately, this volume figures 950 cu.ft., which reduces to 7 cu.ft. per square foot of grate, and when burning 30 lb. of coal per hour per square foot of grate, the furnace volume becomes 0.23 cu.ft. per pound of coal consumed. A suspended arch rising from the gate and then horizontal, in conjunction with a stoker sloping toward the rear, gives expanding volume for the volatile, and a restricted throat between arch and bridge-wall, with expanding volume toward the tubes, helps to mix the air and gases so that proper combustion may be

attained before reaching the heating surface. The boiler is baffled for three passes, with the front baffle sloping forward to reduce the gas passage in conformity with the reduction in temperature and the corresponding shrinkage in volume of the gases.

A radial-brick stack resting on a concrete slab at the roof and supported by steelwork serves the four boilers. It rises 235 ft. above the grate and is 10 ft. in diameter at the top. The location is central and symmetrical breechings on either side rise and merge and seven square feet of grate area. On the basis of 100 sq.ft. of steam-making surface, 2.3 sq.ft. of grate, 0.404 sq.ft. of breeching and 0.337 sq.ft. of stack have been installed.

Coal for the plant is dumped from railway cars into a track hopper, and by means of an apron conveyor is transferred to a continuous bucket carrier which delivers to the overhead bunker. The latter, which was designed by company engineers, is of parabolic cross-section, with individual sections for each boiler, and

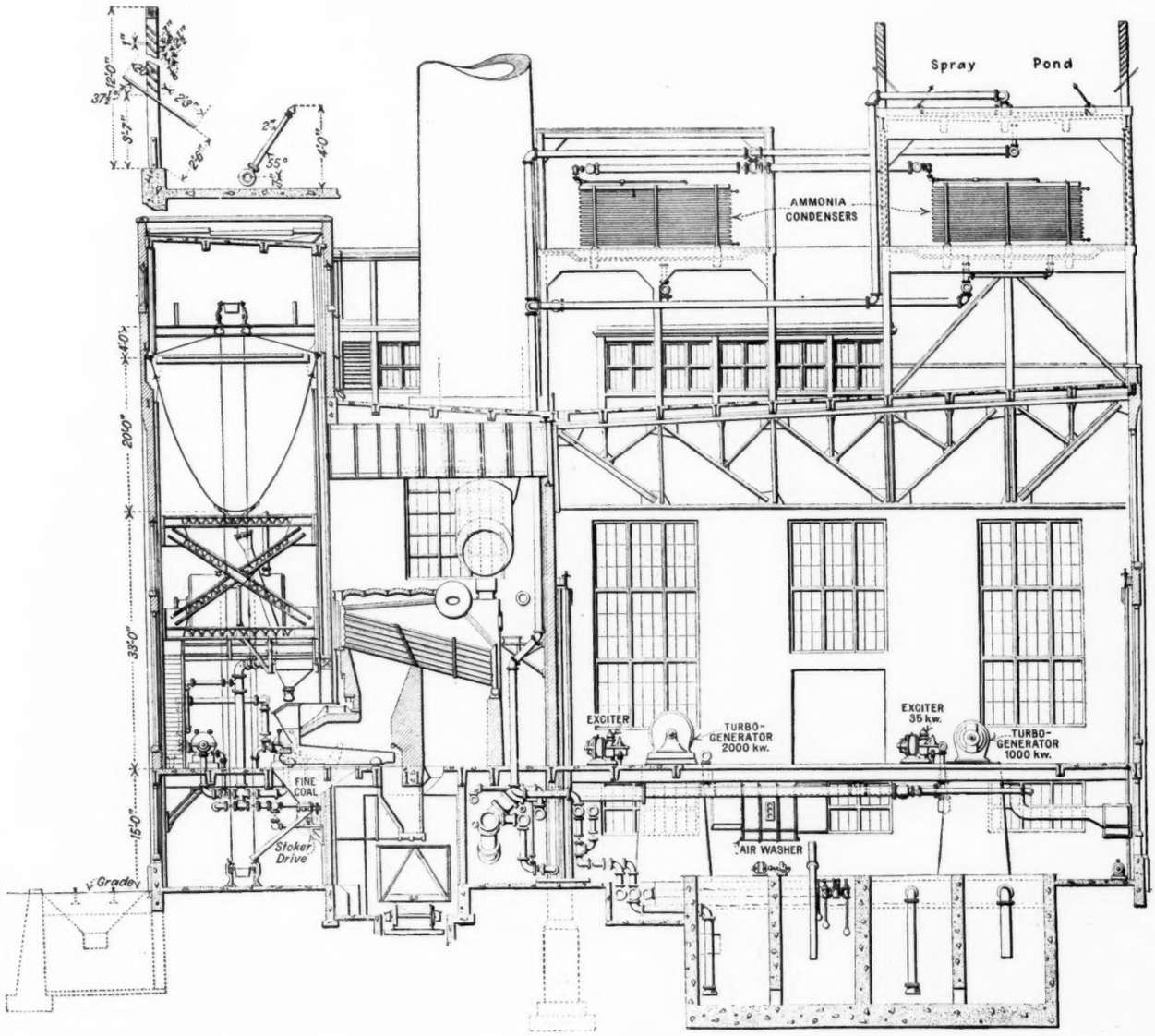


FIG. 3. CROSS-SECTION THROUGH ARMOUR KANSAS CITY POWER HOUSE

into a common flue discharging into the base of the stack. The breeching is circular and of cross-section tapering from 3 ft. diameter to 7 ft. 9 in. An easy turn at the stack and uptakes sloping with the run give a breeching offering minimum resistance to the flow of gases. The construction is of steel, lined with vitrobestos. Temperatures at the uptake are below 500 deg. F., a test at 175 per cent of rating showing a gas temperature at the outlet of 480 deg.

From data previously given one square foot of stack area serves, in round numbers, thirty boiler-horsepower has a capacity of 400 tons, a thirty-six hours' supply for the boilers. Provision has been made for a coal crusher, but as yet it has not been installed, as the intention is to burn screenings and fine coal that does not need crushing. The capacity of the conveying equipment is rated at 50 tons per hour. From the bunker the coal gravitates through chutes into a traveling weigh larry and is then passed on to the stoker hoppers. Underneath the chain grate a fine-coal hopper has been provided, which delivers directly to the continuous bucket conveyor, and at the rear ash hoppers

discharging directly into railway cars. This was possible as the basement floor line is practically at grade level.

Any one of three separate and distinct lines may be used to feed the boilers. Two of these lines are served by turbine-driven centrifugal pumps and the third by injectors. The original source of supply is the city mains. The water is first passed over ammonia condensers on the turbine-room roof, where during the colder months its temperature is raised to approximately 90 deg. It then gravitates to the jet condensers serving the turbo-generator units, and is delivered at a temperature of approximately 110 deg. F. to a large hotwell by the removal pump of the jet condenser.

By means of turbo-driven service pumps a part of this water is transferred to an open metering heater rated at 1,400 hp. and having sufficient capacity to serve the entire plant when completed as originally planned. The water is taken from the heater by turbine-driven boiler-feed pumps and discharged to the boilers under the control of feed-water regulators.

Water from the hotwell is delivered also to a spray pond located on the roof over the ammonia condenser. The sprays, twenty-four in number, will be used normally to cool 2,200 g.p.m. within three to five degrees of atmospheric temperature, although they have capacity to handle 2,800 g.p.m., and this in a floor space measuring 74 x 30 ft. From Fig. 3 it will be seen that the nozzles are arranged twelve on either side of the pond and spray toward the center. They are supplied by headers reducing from 8 to 4 in. in diameter as they progress toward the far end of the pond. The centers of the headers are within 7 in. of the concrete spray deck, but the nozzles rise to a height of 4 ft. above the floor and are set at an angle of 55 deg. with the horizontal.

To keep the spray within bounds, the louvers are set at a greater angle than usual and comparatively close, the inside edge of any board being one inch lower than the outside edge of the board below it. Near the outer edge of each board is a grooved recess to catch the spray and turn it back. Under the louver construction is a 51-in. baffle having the double function of keeping back the spray and of directing a current of air along the jets from the nozzles.

During the colder months this water gravitates over the ammonia condenser, through the jet condensers and is returned to the hotwell to be used as previously described. In summer it is impossible to cool city water below 100 deg. F. Consequently, deep-well water having a temperature of 65 deg. is passed over the ammonia condenser and is discharged to the sewer. City water from the spray pond is passed through the jet condensers and on to the hotwell as before. A cold well fed from the city mains under float control maintains the plant service and supplies makeup as needed for the hotwell.

As an addition to the refrigerating capacity a 500-ton horizontal cross-compound compressor has been installed in the new plant. The steam piping has been arranged so that in the event of either ammonia cylinder becoming incapacitated, the other side of the machine can be operated at reduced capacity; for example, the low-pressure side can be supplied with steam through a reducing valve at 60 lb. pressure. The condenser serving the unit just referred to is of the atmospheric type. It contains 60 stands, 24 pipes high of 2-in. pipe, 20 ft. long.

As in every other packing house, there is a great demand for steam in the various manufacturing processes and large quantities of hot water are required. It is economical to utilize exhaust steam from which mechanical energy has been derived, and it requires careful planning to balance the supply against the demand. To give some flexibility in this regard, mixed-pressure bleeder turbines drive the generating units, of which there are two, one rated at 2,000 kw. and the other at 1,000 kw. Both machines are served by jet condensers.

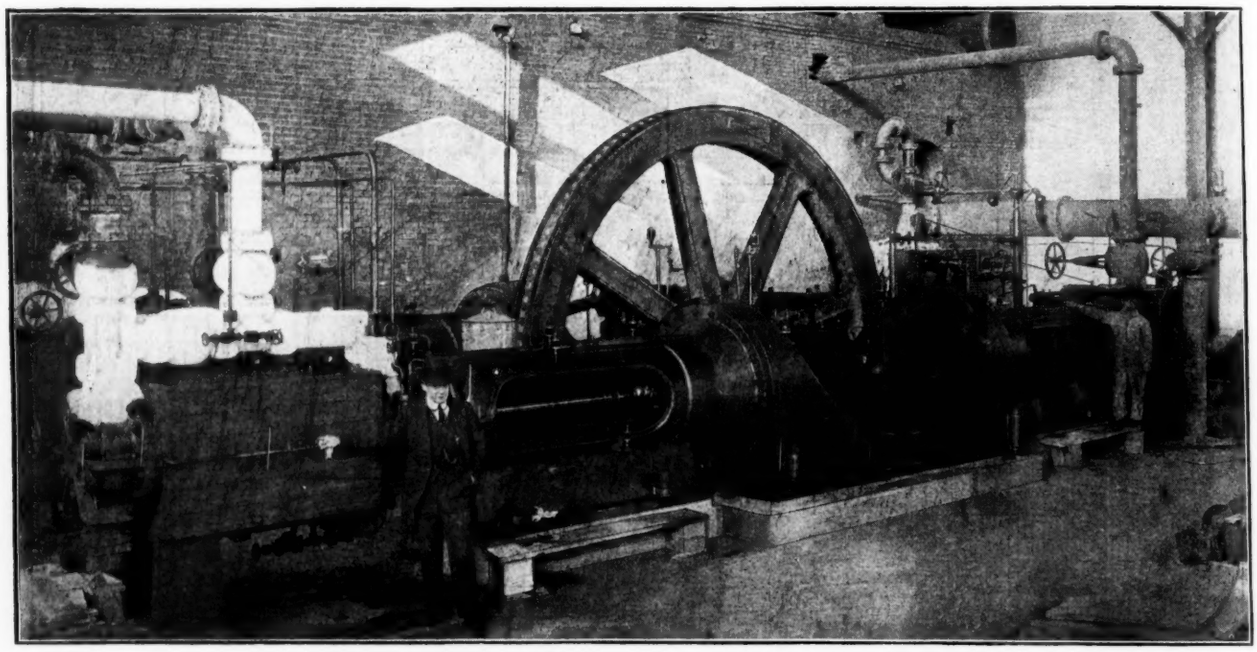


FIG. 4. VIEW OF NEW SIX-HUNDRED-TON ICE MACHINE

At the works they are beginning to change over a portion of the motor load to alternating current, and until this change is completely effected a temporary 750-kw. rotary converter set will be operated in conjunction with the new 2,000-kw. alternator that is now in operation. The new distribution system is designed for operating at 8,300 volts with transformers at the respective stations to convert to 440 volts three-phase 60 cycles for power and 110 volts single-phase for lighting. The present power current is 550 volts d.c. and the present lighting is 1,100 volts a.c. The old 550-volt d.c. generators will be retained for emergency purposes and will work in conjunction with the rotary converter, which is designed for reverse operation when required; that is, from direct current to alternating current, to take care of the new installation of alternating-current motors.

Cooling air for the generators is washed, an air washer being provided with each unit. Outdoor air enters the intakes and the discharge is to the basement. Two 35-kw. turbine-driven exciters have been installed, although one machine will supply sufficient excitation for the two units.

It will be noticed that practically all of the auxiliaries in the plant are turbine-driven, and as they operate non-condensing, there is considerable exhaust steam available. While the 500-ton ammonia compressor is equipped with a jet condenser, it discharges normally in conjunction with the auxiliaries mentioned into a common exhaust main 24 in. in diameter, making the entire circuit of the plant and supplying all requirements for low-pressure steam. In this exhaust line a pressure of 5 lb. gage is maintained. If this pressure tends to drop, steam is bled from the turbines to make up the deficiency, and when the pressure in this line exceeds 5 lb., the flow is into the turbines, so that power that would otherwise be wasted may be recovered from the exhaust steam. All this takes place automatically, so that within the limits of the turbines there is no difficulty whatever in maintaining an exhaust balance.

From the turbines the steam is exhausted to jet condensers, and the heat in the mixture of condensation and cooling water is conserved by pumping the condenser discharge to the hotwell. To effect the balance desired, it will be evident that at times the generating units will operate as extraction turbines, sometimes as condensing units and at other times as low-pressure turbines, or as combination units using both high- and low-pressure steam. It will be realized that supplying the feed-water heater with sufficient exhaust steam for its requirements is one of the functions of the exhaust line.

Complete utilization of exhaust steam in this way makes for efficiency, and in this regard a packing house, with its large steam requirements, possesses a decided advantage over the average industrial plant. The new plant is now in operation, and from all indications is showing marked economy in the generation and use of steam. All engineering was done by the motive-power department of Armour & Co., of which A. McKenzie is superintendent.

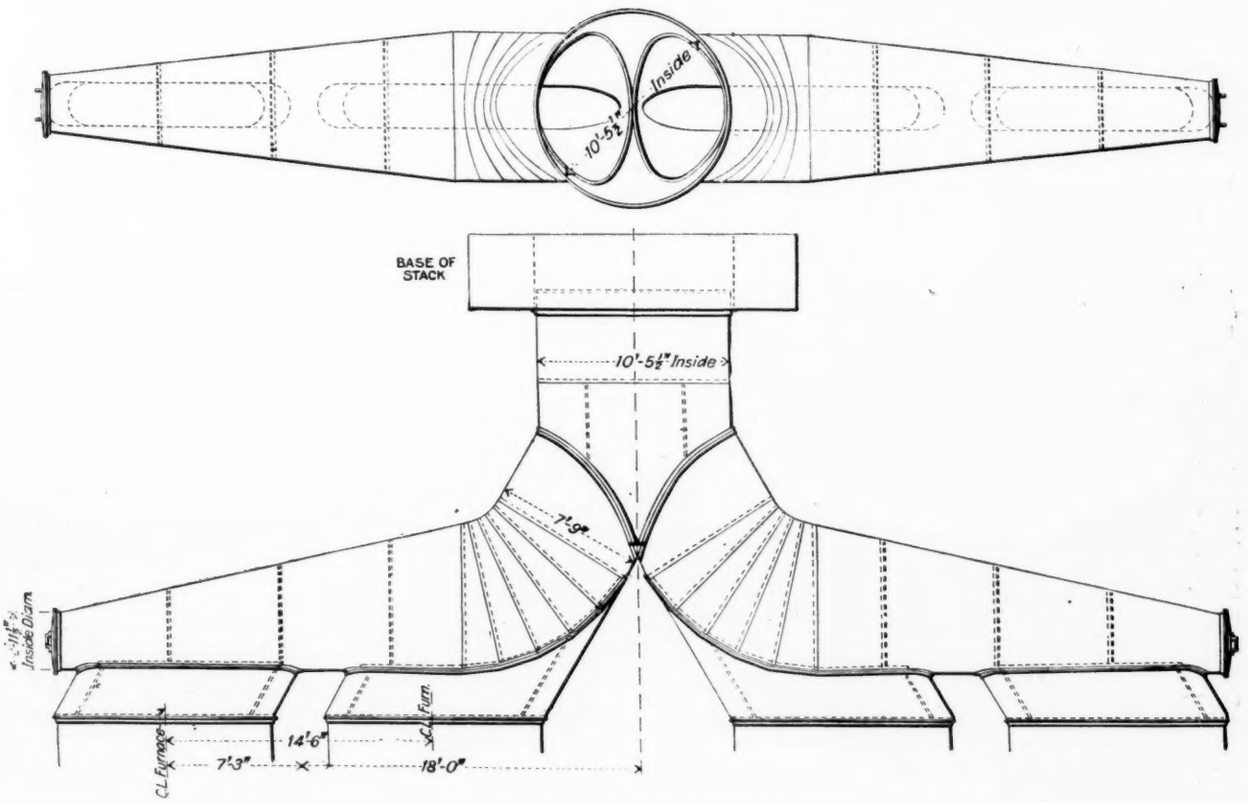


FIG. 5. BREECHING FOR THE NEW BOILER HOUSE OF THE ARMOUR COMPANY

The Diesel engineer should study his engine and the method and theory of operation as closely as does the steam engineer. Considering the length of service necessary as an oiler or helper, Diesel engineering offers far more opportunity than does steam engineering.

Speed Control of Direct-Current Motors in Ventilation Service

By WILLIAM H. EASTON
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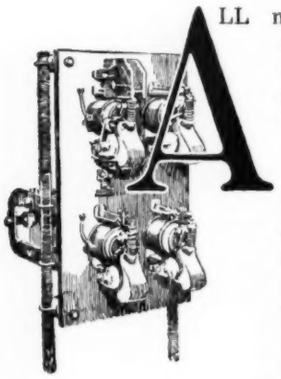
The purpose of this article, which supplements one by the author on "Motors for Driving Ventilating Fans" (Power, May 11, 1920), is to discuss the various types of speed control for direct-current motors in ventilating service and indicate a method for determining the most economical type of control for a given installation.



ALL methods of controlling the speed of a direct-current motor are based on the fundamental formula of the motor, which can be written:

$$E = e + IR$$

in which E is the applied electromotive force; e, the counter-electromotive force generated by the motor; I, the current passing through the armature; and R, the resistance of the armature circuit. In other words, a part of the energy received by the motor is absorbed as losses due to the resistance of the armature circuit, while the greater part of the remainder is balanced by the energy generated by the motor, which of course acts as a generator when it is in operation. The motor maintains this relation of forces automatically, changing its speed to correspond with any changes in the other factors.

Speed Adjustment by Armature Control

It is evident that if the losses in the armature circuit are increased by increasing its resistance, the counter-electromotive force needed to form a balance will decrease and the motor will slow down. This is the principle of armature control, which is carried out in practice by connecting, in series with the armature circuit, resistance that can be varied by turning a regulating handle.

The method is, however, inherently wasteful, and in applications where the load remains constant at all speeds, as with printing-press drive, the energy lost in resistance at low speeds may considerably exceed that used for actual work. But with a centrifugal fan the load falls off very rapidly as the speed decreases (varying, in fact, as the 2.5th power of the speed), so that the energy losses at low speed with this method of control are much less than those with a constant-load drive. The maximum loss occurs at a speed reduction of 57 per cent and amounts to about 19 per cent of the motor's full-load input, and though this loss is fairly large, it is not prohibitive for many applications.

Armature control is essentially a method of speed reduction. If the speed of a motor is to be varied over a range of from 200 to 400 r.p.m. by this method, a machine with a normal speed of 400 r.p.m. is selected and the controller arranged for a 50 per cent speed reduction.

Speed Adjustment by Field Control

Since the counter-electromotive force generated by a motor is determined by the speed of its armature and the strength of its field, a decrease in the strength of the field necessitates an increase in the speed of the armature to maintain the balance indicated by the motor formula. By connecting an adjustable resistor in series with the field circuit of a motor the speed can therefore be varied at will within the limits imposed by the motor's design. This gives a method of speed regulation known as field control.

The operating efficiency of this method is high, for under all conditions the amount of energy lost in the field resistor is a negligible quantity. But on the other hand, the first cost of a motor to be operated over a given speed range by field control will be greater than that of a motor of the same horsepower to be operated over the same range by armature control. This is accounted for by the fact that the fields of the former must be larger than those of the latter in order to produce the necessary horsepower when the field current is weakened to produce maximum speeds. Motors to give a wide range of speeds by field control must, in fact, be specially designed for this purpose. The standard ranges are 1 to 2, 1 to 3 and 1 to 4.

Field control is regarded as a method of increasing the speed of a motor. Hence, when a speed range of from 200 to 400 r.p.m. by field control is required, a motor with a normal speed of 200 r.p.m. and a controller giving a 100 per cent increase in speed are selected. Care must, of course, be taken to select a motor capable of producing the horsepower desired at its maximum speed.

Combined Field and Armature Control

The objection to armature control is, therefore, its wastefulness at low speeds, while the objection to field control is the higher first cost of a motor to operate at increased speeds. In order to provide a compromise between these objections, controllers can be arranged so that part of the speed range is effected by field control and part by armature control. Thus, to obtain a speed range of from 200 to 400 r.p.m., a motor with a normal speed of 300 r.p.m. can be used, with a controller that will provide the 300 to 400 r.p.m. range by field control and the 300 to 200 r.p.m. range by armature control. With this method the first cost of the motor will be less than with straight field control, and the energy losses less than with straight armature control.

The following conclusions are obvious from the foregoing discussion:

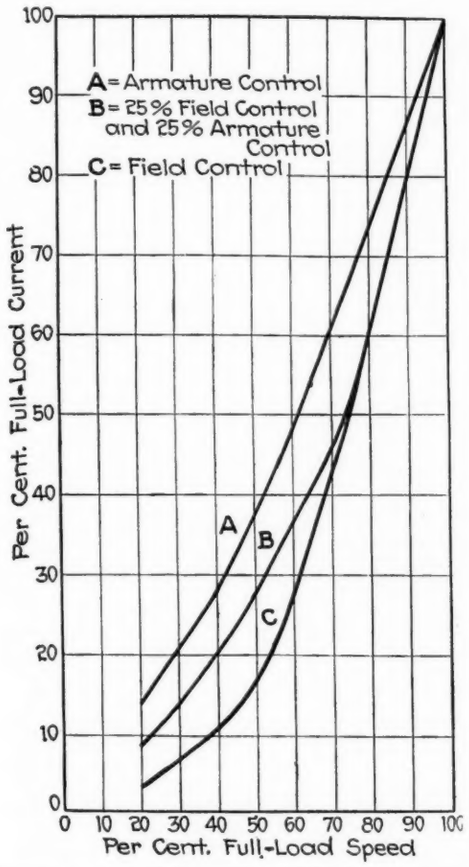
1. If the motor operates at its maximum speed practically all of the time, with only occasional periods

of operation at slightly reduced speeds, armature control should be selected.

2. If the motor operates mainly at low speeds but is occasionally operated at much higher speeds, field control should be selected.

3. If the motor's speed is being constantly varied over a wide range, combined field-and-armature control will probably prove the most economical method.

But in order to determine accurately the most economical method for a given application that does not clearly fall into either of the first two classes, it is necessary to calculate the cost of the power consumed by motors under each of the three methods of control for a period of, say, a year and compare these costs



VARIATION IN POWER, CONSUMPTION OF MOTOR OF 10-KILOWATTS NORMAL INPUT

with the interest and depreciation costs of the motors and controllers.

The calculation of the current consumed can be facilitated by reference to the accompanying curves, which show the percentages of full-load power taken by a motor when driving a centrifugal fan at various speeds under each of the three methods of control. Assume the following simple example:

A motor of 25 hp. normal rating, at maximum speed, is required to drive a ventilating fan 365 days a year, 12 hr. at 400 r.p.m. and 12 hr. at 200 r.p.m. each day. The installation is expected to be operated at least ten years; cost of current is one cent per kilowatt-hour; and the motor manufacturer quotes price on motors and controllers as follows: For armature control, $990; for armature-and-field control, $1,130; for field control, $1,300. Which method of control will be the most economical in the long run?

The first step is to calculate the cost of the current consumed. The full-load power consumption of the motor will be $\frac{25 \times 0.746}{86.5} = 21.6$ kilowatts, where 0.746 is the factor to change 25 hp. into kilowatts and 86.5 is the per cent efficiency of the motor according to the manufacturer. As there are 8,760 hours in a year, the motor will operate 4,380 hours at full speed and the same number at reduced speed.

By all three methods of control the amount of power consumed at maximum speed will be the same; namely, $21.6 \times 4{,}380 = 94{,}608$ kw.-hr. But as shown by curve *A*, the current consumed during the 50 per cent reduced-speed period will, under armature control, be 39 per cent of this, or $94{,}608 \times 0.39 = 36{,}897$ kw.-hr.; at reduced speed curve *B* shows that the current under field-and-armature control will be 28 per cent, or $94{,}608 \times 0.28 = 26{,}490$ kw.-hr.; and as shown by curve *C* the current with field control will be 17 per cent, or $94{,}608 \times 0.17 = 16{,}083$ kw.-hr. Then the total kilowatt-hour use for armature control is $94{,}608 + 36{,}897 = 131{,}505$; for field and armature control, $94{,}608 + 26{,}490 = 121{,}090$; and for field control, $94{,}608 + 16{,}083 = 110{,}691$. Therefore the total cost of power per annum at one cent per kilowatt-hour will be: With armature control, $1,315; with field-and-armature control, $1,211; with field control, $1,107.

Most Economical Type of Control

By comparing the cost of a motor for armature control with that of a motor for field control, it is found that although $310 first cost will be saved by using armature control, a saving of $208 a year will be effected in power costs by using field control; and by comparing combined field-and-armature control with field control, a saving of first cost of $170 is found in favor of the former and a saving of $104 per year in favor of the latter.

Hence in both cases the difference in first cost would be saved in less than two years by using field control, so that for this installation this method is evidently the most economical. And if the cost of current were more than one cent per kilowatt-hour the advantage in favor of field control would be proportionately greater.

The curves given were drawn for a certain motor of 10-kw. input, therefore will not of course apply with complete accuracy to motors of other types and sizes; but the error for the average standard ventilating motor of good characteristic should not be so large as to prevent the use of these curves for ordinary purposes, especially since the number of hours during which the fan will operate at various speeds is usually difficult to determine exactly. For very accurate work the motor manufacturer should be requested to make the foregoing calculation, using the actual performance data and prices of the motors under consideration.

To keep in touch with the operation of the plant and to determine if it is working at the highest efficiency, it is necessary that a correct log be kept of all departments. This log of itself has no value unless it is carefully analyzed from day to day to determine whether the plant did maintain the highest efficiency on each particular day under the conditions at which it was necessary to operate.

The Proper Selection of Fuel for the Oil Engine

By ALLEN F. BREWER

ENGINEERS, power-plant managers and purchasing agents, today, who have to do with the selection of oil fuel for internal-combustion, heavy-oil engines are met with the ever-prevalent question: How is it possible to choose an oil most adaptable to the engines and at the same time most economical? Gradually, we are beginning to realize that fuel-oil specifications and builders' recommendations are but a means to an end, based on the more or less ideal conditions of the testing floor. Any worth-while test is made under somewhat more exacting conditions and requirements than are expected for normal operation of the apparatus, yet it is impossible for the testing engineer to obtain all the abnormal factors that may be met with after the engine has been actually delivered and put into operation by the owners. These may be, altitude, climate, intelligence of labor, fuel oil storage and heating facilities, etc.

It is evident that to follow blindly a set of builder's recommendations or a hard-and-fast fuel-oil specification may frequently result in the purchaser being severely handicapped when it actually comes to burning the oil he has selected. Let it not be understood for a moment that the engine builder's fuel recommendation or the oil manufacturer's fuel specification should be disregarded in any way. By no means. On the other hand, they should be given as great consideration as ever, but with ample thought as to the conditions under which the engine must operate.

The Basis of Purchase

The day of purchasing fuel oil by the barrel or B.t.u. content alone is fast passing into history. More and more must economy of operation be considered, as well as economy in fuel. So, the selection of the fuel must be more carefully made, because the results derived from any oil engine will hinge to a large extent on the grade of fuel. We would not purchase any other commodity in half as haphazard a manner as many engineers have bought their fuel oil heretofore. Whatever the article, it is the inherent impulse of the intelligent man to look carefully into quality, physical properties, durability and ability to do the work required according to actual conditions of use. In other words, we buy for wear or service. So must the selection of fuel oil for the Diesel or semi-Diesel engine be made hereafter if we are to most effectively consume oil.

The heavy-oil engine is perhaps the most sensitive piece of apparatus today, wherein a petroleum product is used. The efficiency derived will depend most acutely on climate, altitude, conditions of operation and the intelligence of the operator. For example, an engine that would show excellent efficiency in New York when tended by an expert engineer, might perhaps fail utterly on the same fuel oil if in operation in a mine in the Andes Mountains, where the labor employed is of the ignorant native type.

The prime object in operating any power-generating equipment, such as the Diesel engine, is to attain the utmost economy under the prevailing conditions of operation. The chief demand of economy is that suitable fuel, to burn under these conditions, may be obtained whenever and wherever required and in the quantity required, at the cheapest price per barrel. The chief requisite for efficiency is that the engine can be properly made to burn this fuel by the labor at hand and under the peculiar conditions that may be present. Wherever possible, an effort should be made to use the heaviest fuel thus available, since the heavier the oil the greater heating value it will have per barrel and the cheaper it will be.

Physical and Chemical Properties

Whatever the grade of fuel oil to be burned in a Diesel engine, there are certain physical and chemical properties or characteristics, as already referred to, which must be given due consideration by the purchaser in making his decision as to a fuel best adapted to meet his operating conditions. General properties that should prevail, whatever the oil, are: That it should be free from incombustible solids such as dirt, grit, etc.; that it should not contain more than one per cent water; that it should be sufficiently mobile at operating temperatures as not to require excessive preheating.

The more varying physical and chemical characteristics are classified here, and briefly discussed, in order of their importance.

1. Range of Boiling Points—Of all characteristics perhaps the most important guide to the purchaser is the range of boiling point, since it indicates the degree of vaporization possible, the burning power of the oil and the extent to which it will gasify. The greater the proportion of distillate between 400 and 750 deg. F., the better will be the properties mentioned. A statement of range of boiling points set forth in 10 per cent fractions of distillation is therefore of utmost importance to the purchaser and should be furnished by the oil manufacturer.

2. Water Content—This is detrimental for three vital reasons: There is danger of water slugs carrying over to the fuel valves causing faulty firing; the danger of chemical action with sulphur in the oil, to cause ultimate corrosion within the engine by formation of sulphurous-acid gas; the fact that water lowers heating value and entails fuel consumption for its evaporation. Water content in Diesel or Semi-Diesel engine fuel oil should not exceed 0.3 to 0.5 per cent normally; or 1 per cent at an outside maximum.

3. Ash Content—Ash to any extent in a fuel oil will cause abrasion of cylinders (necessitating frequent cleaning of the engine) and excessive wear. No such oil should contain above 0.01 per cent of ash as determined by actual evaporation test.

Sediment Content—In general, sediment content will have the same effects that high ash content would; that is, abrasion, excessive wear, etc. As a rule sediment or dirt will contain a large percentage of silicates, which will tend to become incorporated with the lubricating oil and cause abrasion and scoring. It is commonly agreed that there shall be practically no such foreign matter in a Diesel fuel oil; it can be removed by proper straining, and this should be done always, prior to use in the engine. The opportunities for entry of dirt during handling, transit, etc., are great, hence as a safeguard

never draw an oil below one foot from the bottom of the storage tank, and sample and test frequently.

5. Sulphur Content—The ultimate effects that high sulphur content in a Diesel fuel oil may have on the engine has been the subject of varied discussion recently. The common belief is that sulphur in the presence of water vapor will oxidize and react to form sulphurous acid. To what extent this may occur will, of course, depend on the amount of water in the oil. With a low water-content oil sulphur as high as 3 to 4 per cent should have no detrimental effects as regards corrosion. The reaction prevalent between sulphur and the lubricating oil is, however, of considerable importance, whatever the percentage of the former, owing to the fact that a gummy substance will result, reducing the lubricating properties of the lubricating oil and necessitating frequent cleaning of the engine. It is generally assumed that a fuel oil for Diesel-engine use should contain less than 3 per cent sulphur in order to be satisfactory from the foregoing points of view.

6. Coke Content—The coke content is of particular interest because it involves the presence of a practically non-combustible solid in the oil, and ultimately in the engine. Using an oil of high coke content, only the petroleum hydrocarbons will be effectively burned, the coke residue remaining in the cylinders to a major extent, adhering to valves, seats and liners, fouling the valves, scoring the wearing surfaces, counteracting the effects of the lubricating oil and increasing the need for cleaning and repair. In a Diesel-engine fuel oil 5 per cent coke is generally considered as the maximum working limit, although the less the coke content the less, of course, will be the detrimental effects.

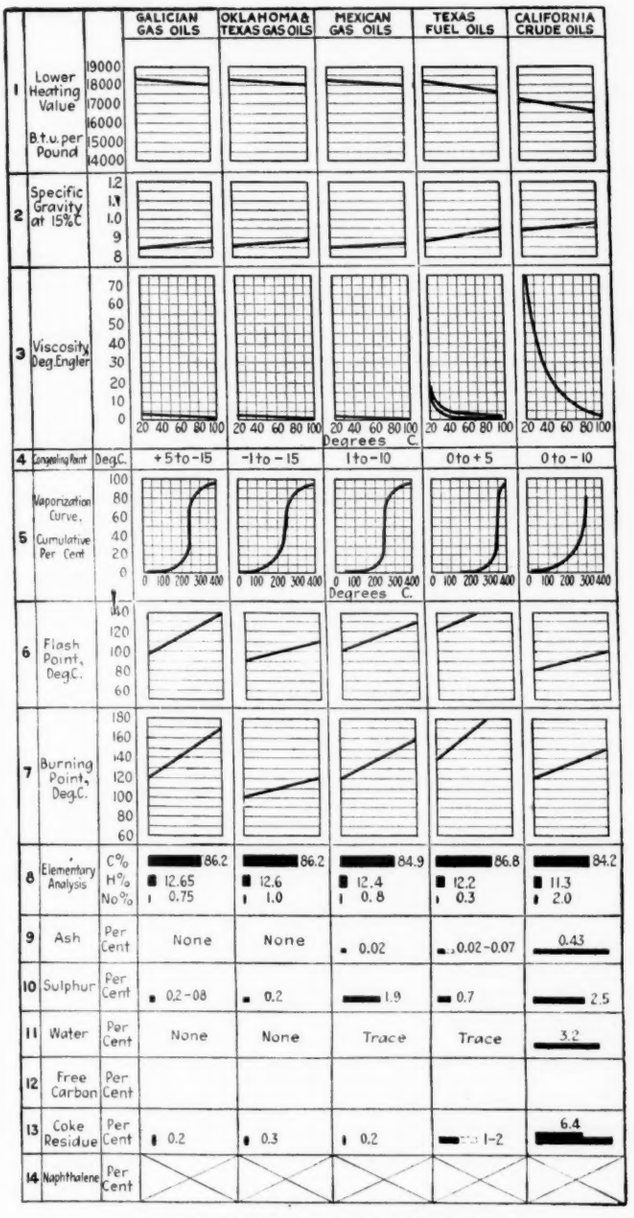
7. Acidity—Acidity, in general, should be entirely absent in any engine fuel oil. The objectionable feature is, of course, that excessive corrosion would result.

8. Flash Point—The flash point is of most importance to the consumer as a guide to the safe storage properties in the oil, it being the temperature at which the latter will give off vapors to form an inflammable gaseous mixture with air. The higher the flash point the lower the content of excessively volatile constituents. A flash temperature of 150 deg. F., by closed cup test, practically assures a sufficiently low content of high volatiles to allow of free handling and safe storage; it is generally taken as the minimum flash temperature in the trade today.

9. Viscosity—Viscosity, or more plainly, the relative fluidity of the oil as compared to a water standard usually is of particular interest to the purchaser where he may encounter difficulties in flow due to excessive cold weather or sudden temperature drops, coupled with lack of heating facilities in storage tanks, excessive length of piping to be pumped through, or insufficient pump capacity. The oil, by actual test, should prove itself of sufficient mobility to flow properly at the lowest atmospheric temperatures under which it is to be pumped to and burned in the engine. Owing to the fact that viscosity decreases with temperature, it is also a general guide to the consumer as to the extent that he must preheat the oil in question in order to insure proper and continuous flow.

10. Gravity—Although a fuel oil is generally spoken of in terms of its Baumé gravity, the latter is not a particular guide as to the fuel properties of the oil. It is, however, of interest to the consumer as a general indication of the relative fluidity of an oil at 60 deg. F.; that is, the lower the gravity the greater will be the viscosity, and hence the resistance to flow. Gravity is also a guide as to the calorific value; that is, the lower the gravity and the heavier the oil, the more heat units will it contain per unit volume.

11. Calorific Value—The calorific value is of little importance to the purchaser as an indication of the suitability of the fuel oil in question for his engine.


GALICIAN GAS OILS
OKLAHOMA & TEXAS GAS OILS
MEXICAN GAS OILS
TEXAS FUEL OILS
CALIFORNIA CRUDE OILS
1 Lower Heating Value B.t.u. per Pound
2 Specific Gravity at 15°C
3 Viscosity Deg. Engler
Degrees C.
4 Congealing Point Deg. C. +5 to -15 -1 to -15 1 to -10 0 to +5 0 to -10
5 Vaporization Curve. Cumulative Per Cent
Degrees C.
6 Flash Point, Deg. C.
7 Burning Point, Deg. C.
8 Elementary Analysis C% H% No% 86.2 12.65 0.75 86.2 12.6 1.0 84.9 12.4 0.8 86.8 12.2 0.3 84.2 11.3 2.0
9 Ash Per Cent None None 0.02 0.02-0.07 0.43
10 Sulphur Per Cent 0.2-08 0.2 1.9 0.7 2.5
11 Water Per Cent None None Trace Trace 3.2
12 Free Carbon Per Cent
13 Coke Residue Per Cent 0.2 0.3 0.2 1-2 6.4
14 Naphthalene Per Cent

PROPERTIES OF TYPICAL OILS

Of course, the higher the heat content in British thermal units or calories, the more desirable the oil from an economical point of view. On the other hand, other more important properties should never be sacrificed to obtain a fuel of highest calorific value. In general, there is little variation between 18,000 and 19,000 B.t.u. per lb. for any fuel oil on the market today.

Having at hand, and considered, the physical and chemical properties of the fuel oils available, the next step is to review conditions under which the oil most favored is to be burned. Assuming all the chemical properties to be satisfactory, viscosity essentially is the

guiding physical factor, inasmuch as the problem of flow will be most pertinent in nearly every case. Prevailing temperature, dependent on both altitude and locality, must be the first consideration, along with the location of storage tanks, length of oil transmission pipe therefrom to the engine, the manner of laying or burying such pipe, extent of frost, etc. It is perfectly evident that in the tropics a far heavier-gravity oil will flow freely through the pipe line under average temperatures than would be the case in more frigid localities.

Preheating facilities in the storage tank is the next point of importance. Preheating will be a practical necessity in a cold climate to effectively burn an oil below about 30 deg. Baumé gravity. In the absence of such heating coils the maximum low atmospheric temperature should always be ascertained before the fuel oil is finally selected. If necessary, cold and pour tests should be run to note the extent of mobility of such an oil. An otherwise suitable oil, able to meet builder's recommendations, may frequently have to be rejected for a lighter, more expensive oil, solely for the reason that it will not flow freely from the storage tank to the engine under prevailing maximum low temperatures. Whether to take a chance on the heavier oil depends on the seriousness of impromptu shutdowns. If they are not of material account, the heavier, cheaper oil may well be used.

The question of elevation of the storage tank in respect to the engine and the capacity of the pump available is the third important factor. The heavier the oil, particularly if flow is against a material head, the greater must be the capacity of the pump. It is quite evident that it would be folly to purchase an oil of so low a gravity as to put a constant overload on the transmission pump or so heavy as not to flow to the engine in sufficient quantity to meet consumption. Such an oil might amply meet recommendations, yet the logical course would be to purchase a lighter oil which would not involve the possible difficulties mentioned.

To burn a fuel oil of normally low gravity in the Diesel or semi-Diesel engine successfully will necessitate a certain degree of intelligence on the part of the operating engineer. Both in operating or repairing he must "use his head." So, we have the final important operating factor to consider before the oil is purchased. The lighter the fuel, the less danger will there be of sudden shutdowns or need for adjustment due to clogging of the fuel valve, cylinder deposits, carbonization, or imperfect flow of the oil.

In brief, then, to select a fuel oil for any Diesel or semi-Diesel engine plant in the most efficient and economical manner, we must consider:

1. The engine builder's recommendations.
2. The oil manufacturer's specifications of physical and chemical properties for the fuel oils available at the particular place and time when needed.
3. The peculiar conditions under which operation is normally carried on, including temperature, labor, pumping facilities, storage, and facilities for fuel transmission.
4. The extent to which an oil described under paragraph 2 and recommended under paragraph 1 above, will meet conditions existing under paragraph 3.
5. In making the selection, the purchaser should not ignore the heavy fuel oils which are offered on the Atlantic Seaboard at a price much below the distillates. Although the dirt and coke contents are objectionable, many engines have used 12 deg. Baumé Mexican oil.

Economic Value of Coal—III. Falling Off in Heat Content

By B. S. MURPHY

A comparison of the relative value of anthracite and bituminous coal based on the effective heat content in each shows that anthracite not only costs less but is actually worth more.

THE calorific value of all coals has fallen to a marked extent during the last few years, and this loss has been more pronounced, if anything, for anthracite. To show this falling off in the quality of the anthracite as received from 1911 to 1920 at one station, the table herewith has been prepared. All this coal was purchased from the same contractor, and though it did not all come from the same colliery, over 95 per cent originated in the same region. From 1911 to 1917 up to 30 per cent to possibly 40 per cent was No. 1 buckwheat, the rest being No. 3 with a small amount of No. 4, and this represents the purchase and consumption of some 1,200,000 tons of coal.

The maximum and minimum do not represent isolated samples, but are the maximum or minimum months for the period considered. To show just what a falling off as shown means, we will assume a station where the 100 per cent performance with 12,000 B.t.u. coal was 3 lb. per kilowatt-hour. We will also assume that the average calorific value of the coal supplied to this station from 1911 to date was the same as given in the table. Now referring to Fig. 1 we will first draw the standard performance curve assumed that for 12,000 B.t.u. coal the station will turn out a kilowatt-hour for 3 lb. of fuel, or the first point will be 12,000 B.t.u. against 3 lb. For the other point on this straight line take 10,500 B.t.u. and referring to the curves showing calorific value vs. relative plant economy in the second article of this series (Dec. 14 issue), we find this is 57.5 deficient, or makes 57.5 + 100 = 157.5 per cent of coal, or 1.575 × 3 = 4.725 lb. Plotting this and connecting the two points by a straight line, we have the standard performance curve for this particular station that we have assumed. Then plotting the average

CALORIFIC VALUE OF ANTHRACITE COAL AS FIRED

Year	Maximum	Average	Minimum
1911	11,750	11,523	11,250
1912	11,650	11,428	11,050
1913	12,025	11,741	11,420
1914	12,060	11,912	11,560
1915	11,900	11,712	11,470
1916	11,880	11,563	11,150
1917	11,350	11,170	10,850
1918	11,257	11,070	10,780
1919	11,249	11,044	10,844
1920*	11,105	10,847	10,504

* January to June, inclusive.

calorific value of the coal as fired against the year, from the table, we have the actual B.t.u. curve. From this curve, in conjunction with the curve for standard performance, we find what the standard consumption would be and plot this against the year. Of course, in reality, this curve should not give the actual results, as it is standard practice and not actual practice, and the plus or minus variations would give the actual station performance.

We will now assume, as before, that the station output was 6,000,000 kw.-hr. per month, or 72,000,000 per year, and we will figure the standard coal that may be

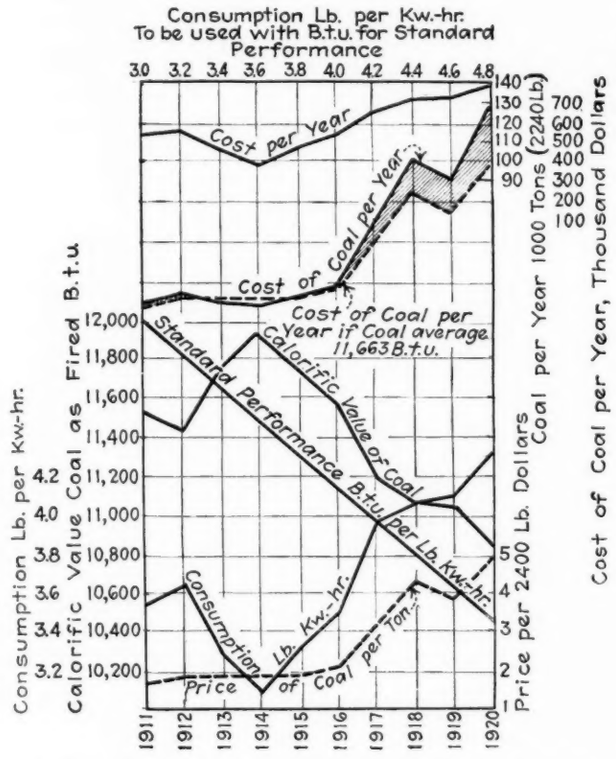

Consumption Lb. per Kw.-hr. To be used with B.t.u. for Standard Performance
Cost per Year
Cost of Coal per Year
Cost of Coal per Year if Coal average 11,663 B.t.u.
Standard Performance B.t.u. per Lb.
Calorific Value of Coal
Consumption Lb. per Kw.-hr.
Price of Coal per Ton
Consumption Lb. per Kw.-hr.
Calorific Value Coal as Fired B.t.u.
Price per 2400 Lb. Dollars
Coal per Year 1000 Tons (2240 Lb.)
Cost of Coal per Year, Thousand Dollars

FIG. 1. EFFECT OF PRICE PER TON ON CALORIFIC VALUE OF ANTHRACITE

used per year for electric generation by multiplying the output of the station by the unit consumption, which we have already arrived at from the calorific value and the percentage deficiency of the coal corresponding. This has been plotted at the top of the graph and shows an allowable increase of 40,300 tons for the year 1920 over the year 1914. This is one phase; more coal made necessary by the lack of heat necessitating a greater money outlay, but at the same time the price of this inferior coal per ton has also gone up greatly, so that we not only use a greater quantity, but pay more for what we do use.

In Fig. 2 has been plotted the relative price of anthracite received at one station from 1911 to 1920, including the latest freight rate in 1920. Based on this current rate as 100 per cent it shows that in 1911 the price per ton was but 34 per cent of that now. Returning to our hypothetical station again and assuming that the anthracite No. 3 now costs $5 per 2,240 lb. at the boiler room and using these same relative values, we would have the price per ton for each year; this has been plotted on Fig. 1 and shows an increase of from $1.69 in 1911 to the $5 of 1920.

We will now compute what the coal cost was per year on these prices and plot these values in Fig. 1, giving us the yearly station cost for fuel. It will be noticed that from 1911 to 1916 there was not a very great difference in the total cost, but that since 1916 it has increased very rapidly. We will now attempt to approximate what has been the total additional money spent directly chargeable to the falling off in calorific value of the coal, allowing the price per ton to vary as already given. To do this, we will average the calorific value for the first five years; that is, from 1911 to 1915 inclusive. This was 11,663 B.t.u., which is equivalent to 3.37 lb. per kw.-hr. Then with this consumption we should burn for our 72,000 kw.-hr. of output per annum 108,300 tons. Then taking the price per ton for each year by this total tonnage, we have the cost per year if the coal had averaged the same for the whole period as for the first five years. The space between these curves has been cross-hatched to represent the

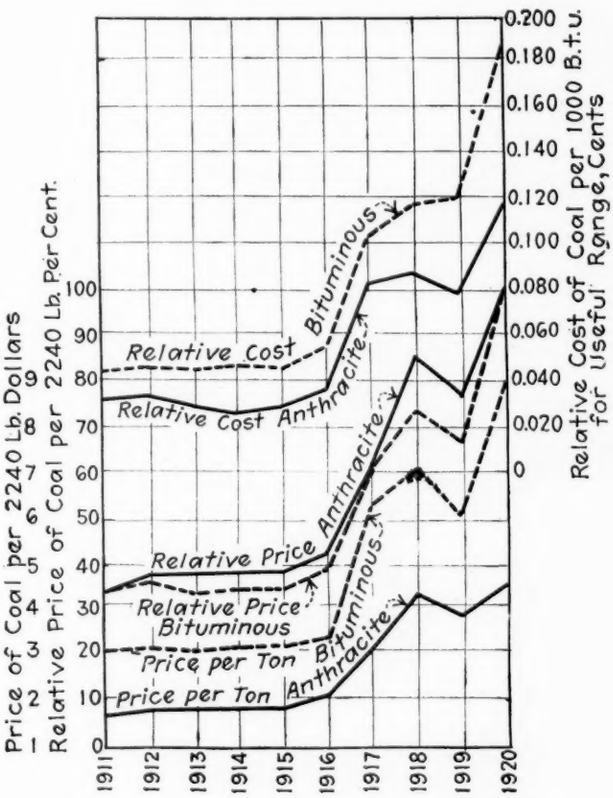

Relative Cost Bituminous
Relative Cost Anthracite
Relative Price Anthracite
Relative Price Bituminous
Price per Ton Bituminous
Price per Ton Anthracite
Price of Coal per 2240 Lb. Dollars
Relative Price of Coal per 2240 Lb. Per Cent.
Relative Cost of Coal per 1000 B.t.u. for Useful Range, Cents

FIG. 2. RELATIVE COST OF ANTHRACITE AND BITUMINOUS COAL

additional money spent owing to the falling off in calorific value. This totals for the ten years $411,000 directly chargeable to lack of heat in the coal, or 12.2 per cent of all the money spent for fuel.

In Fig. 2 has been plotted the relative cost per ton for No. 3 anthracite for a particular station, but from the foregoing analysis of the fuel cost of power we can easily see that, though the price per ton governs the actual money that has to be expended, it tells but little of the relative value of the particular fuel to the plant.

For a proper comparison we must use a figure based on the expected or standard performance of the coal itself or, expressing it another way, how much useful

heat we may buy for a dollar. This term may be called the "relative cost of coal," or the cost per 1,000 B.t.u. in cents, of the heat in the coal above the low limit of its usefulness, or for an anthracite above 9,000 B.t.u. This may be expressed as

Relative cost = price of coal per 2,240 lb., in cents ÷ 2,240 [(B.t.u. per lb. of coal as fired — 9,000) ÷ 1,000].

On Fig. 2 we will now transfer the "price of coal per ton" curve from Fig. 1 for the hypothetical station under discussion, calculating this price from an assumed present-day price of $5 from the relative cost curve for an existing station. From this curve we will take the price per ton, and from the calorific-value curve on Fig. 1 the heat in the coal as fired, and with these figures in the aforementioned formula calculate and plot the relative cost of the coal, or the cost per 1,000 B.t.u. for the useful range, in cents.

We will now figure for bituminous coal on the same assumption as before that in 1920 we had to pay $9 for 2,240 lb. Using actual figures for a large soft-coal central station, we have plotted on Fig. 2 the relative prices, as compared to $9 for a base price, in per cent; this curve is a dotted line, using the dotted lines for the *B* coal values and the solid lines for the *A* coal. It will be noticed that the price variation follows along parallel with that for anthracite and also that the increase during the war, 1918, was not quite so rapid. We will now compute from these relative percentage figures what this soft coal would have cost with the present price of $9 as a base. The next step will be the derivation of the relative cost for this bituminous coal in a manner similar to before and to plot this as a direct comparison with the cost of the anthracite. To do this we will take for the low limit 11,000 B.t.u. and still keeping a range of 3,000 B.t.u., have 14,000 B.t.u. for the upper limit. The formula would then become:

Relative cost, or cost per 1,000 B.t.u. above 11,000 B.t.u. = cost per 2,240 lb., in cents ÷ 2,240 [(B.t.u. per lb. of coal as fired — 11,000) ÷ 1,000]

Substituting the values in this formula of the calorific values for the several years and the price per ton, we have a curve that from 1911 to 1917 is essentially parallel with that for anthracite, but from that time on it varies somewhat. A noticeable feature is that the anthracite not only costs less per ton, but is actually worth more, or we do not have to pay as much for 1,000 useful heat units.

It is never advisable to use thin free-flowing automobile oil on a semi-Diesel. The latter engine requires an oil with a heavier body. It is usually good practice to purchase the oil recommended by the engine manufacturer. To detect a leaky injection nozzle, remove it from the cylinder and reconnect it to the fuel pump. Give the pump handle a few quick jerks. If the check valve in the nozzle is in good shape, the blast of oil will be cut off cleanly without any dribble. The atomizer tip often fills with carbon. An extra one can be used while the old one is being soaked in lye water. A darning needle will be of help in cleaning the oil passage. If the fuel pump has ball-check valves which leak, a few light blows on a hardwood stick or a brass pin placed against the ball will renew the seat. Certain oils carrying much sulphur will attack the balls, giving them a rough surface. Such balls will leak and should be replaced.

Some Ice-Tank Defects

By Gilbert Cox Sellers

Upon visiting an ice plant under construction recently, the writer did not expect to find an establishment built exactly in accordance with the latest requirements for efficiency, but an installation as near to that standard as the unsettled conditions of present-day commerce would permit. The factories cannot secure the material, the railroads cannot deliver, and with the present labor conditions it is not possible to assemble as formerly, even after the material is at the factory. For these reasons we do not build in these times as we know, but we build as we can.

Of course these troublesome conditions bring on unfavorable results, and many defects are brought out. Many of these defects are but exaggerations of faults in construction that have caused trouble ever since ice plants have been built. There is an advantage in the present-day makeshift constructions. The old faults have been shown in their enlargement. Ridicule is the most cutting weapon of logic, and there is nothing that makes a fault more ridiculous than the placing of that fault before us in an enlarged form. The old-time plants had their defects, but we did not see them. The new plants, built from the commercial débris of a score of wars, and from the social unrest of a world's readjustment, necessarily have those faults so enlarged that we *do* see them.

Composite Construction of Plant

In the plant visited, the construction was a real composite outcome of present-day conditions. The builders, nevertheless, skillfully built to completion, putting in substitutes where possible, omitting here a non-essential and leaving a space there for a later installation, portraying in the whole the craftiness of a resourceful designer. However, there were things that could have been done to avoid some of the trouble that is sure to come.

Coils for the brine tank could not be obtained. The engineer, therefore, was forced to do without coils. A shell cooler was substituted. They could not secure oak can covers, so they substituted with soft wood. Throughout the entire tank construction the engineer was forced to follow his own resources. As a result, the tank is a makeshift, to say the best, and the chief is going to have his hands full from the day he harvests his first ice. The first trouble he will find will be in the brine level as compared with the level of the cans. The builders have nailed cleats in the framework for each can. Upon these cleats it is intended the cans shall rest to prevent them from sinking too low in the brine. The brine is supposed to stand immediately below the cleats, which were all placed at the same level. This arrangement would lead one to believe that they expected the brine to maintain a common level. Here is where the trouble will arise. The brine cannot stand at a common level throughout the tank.

To extract heat from the water requires brine circulation and to move the brine there must be a greater head at some part of the tank, such as is imposed by the agitator. At this point the brine will pile up and run down hill. The ice cans will stand low in the brine immediately before the agitator and high above the brine level at the other end of the tank. Besides, a shell cooler had been placed near the agitator, and the cans at this point will be in the coldest brine in the tank.

Over at the other end of the circulation the cans will be suspended out of the brine several inches right where the brine is the warmest and where every square inch of radiation should be brought into play.

Upon mentioning this defect to the owner, he made the remarkable statement that the brine would not pile up if it was forced fast enough. An examination of the tank showed the brine rushing out of the tubes of the cooler against the first cans it came in contact with, doubling back, lapping around the cans and going ahead a few inches, to be dammed up again and escaping only by falling forward to a lower level. It was apparent that the brine must stand so high before the agitator that the cans will lift the covers off of the framework before the cans at the lower end of the tank will be deep enough to freeze in proper time. Knocking the cleats off of the deck frames and arranging the frames so as to adjust the cans to the lowering of the brine level will eliminate part of the trouble, but even then only a part.

Little Chance for Success with Shell Cooler

There is little possibility for success with the shell cooler in ice making in this plant. An improvement might be made by placing the cooler outside of the tank and connecting the chilled brine line to several openings located in the bottom of the tank. The brine might be made to overflow into troughs located along the sides and perhaps down the center. In this manner the brine would not have a long travel before it again reaches the shell cooler and is rechilled, and the efficiency would approach more nearly that of the coil system so generally used. At least the level in such a tank would be uniform. Heat would not be passed from one ice can to another, and the tipping of cans due to agitation would not result.

If the unequal distribution of chilled brine were all of the trouble to be encountered, it could be eliminated later by installing brine coils. But there are other defects. The tank was built on a cinder foundation well packed and covered with a layer of concrete. But the cinders may become soaked at any time. Accidents may happen to the sewer, catch basin or water trap, so that the cinder bed below the tank will be flooded with water. If this happens a few times, or even if the rainy season raises the water level through the sand below, it will mean the loss of thousands of dollars.

Ice will form in the cinders, and the nearer to the center of the tank the thicker will be the ice. This means expansion from below, and the tank will bulge in the middle, lifting the cans out of the brine and causing a loss of efficiency.

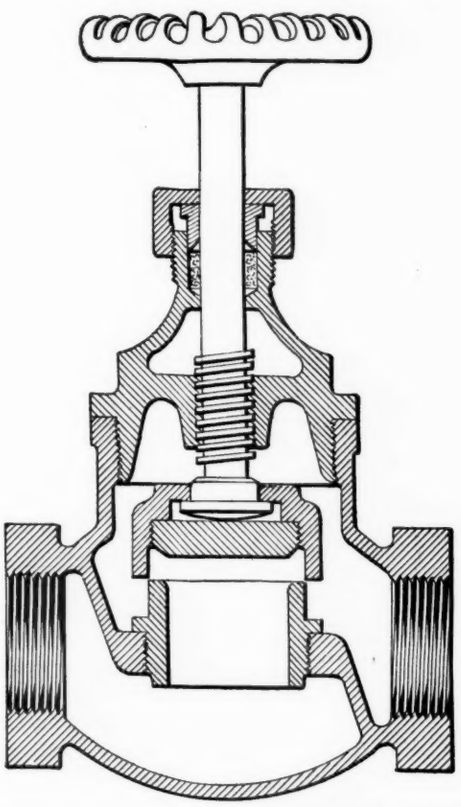
Such a defect is common in tank construction. When a tank is placed on the second floor it can never occur and should not take place on any floor. That it is entirely too common is demonstrated by the fact that of seven tanks that were inspected three were bulged in the center.

Defective Construction Due to Lack of Foresight

Such construction is the result of a lack of foresight, if not a lack of experience. It is unnecessary to build on such a foundation. The tank should be insulated from moisture at the bottom the same as at the sides. No one would think of allowing water to stand about the walls of a tank to freeze even if there were a thickness of five inches of nonpariel cork board to hold off the moisture and to prevent the transmission of heat. There is no need either to allow water to approach the frost line from below the tank. Lay a cinder foundation for the tank with a concrete surface and place on this foundation concrete piers at least ten inches high and close enough to sustain the weight of the tank. On these piers lay a board floor and on the floor place the cork board. Build the tank on this foundation and drain the entire floor to the sewer through a water trap situated beyond the frost zone. With this construction the tank will never bow in the middle. If objection is made to the cost of construction, it would be well to begin figuring on the ultimate cost of reconstruction.

B. & O. Protected Seat Valve

In the protected seat valve manufactured by the Protected Seat Valve Co., Peoples Bank Bldg., Pittsburgh, Pa., the seat is protected from the flow of liquid or gases before the valve disk seats. This is accomplished by sleeves that telescope when the valve is being closed,



SECTION THROUGH PROTECTED SEAT VALVE

thus reducing the velocity of the fluid to a minimum. The seats are self-cleaned by this low velocity before they make direct contact. When opening, the valve disk is raised above the zone of circulation before the telescoping sleeves disengage. If the sleeves are slightly disengaged the high velocity of liquid or gases cannot mar the seat.

The distance between the ground seats is several times greater than the area of the opening when the sleeves are slightly disengaged. The valve is adaptable for use with muddy water, etc. The seat and disk are easily removed, but the disk construction is such that it cannot become loose from the stem. Pressure may be applied from either side of the seat, but it is recommended that it be applied from the top.

The Development of Low Level Multi-Jet Condensers

By C. R. MAY* and N. E. TAYLOR*

THE multi-jet condenser was first described in *Power* in the issue of Sept. 14, 1909. Since that time notable strides have been made in the development of turbine and condenser practice. The condenser described in 1909 is illustrated on this page, Fig. 1, and the fundamental principles remain the same in the condenser built today. Until recently the general impression has been that multi-jet condensers were suitable only for small installations and moderate vacuums. The facts are that modern multi-jet condensers are suitable for all sizes of turbines up to units of 10,000-kw. capacity or even more, and in commercial operation are maintaining vacuums of 28 to 29 in. referred to a 30-in. barometer. The low-level multi-jet condenser was designed and developed by Koerting. His original idea was the elimination of an inefficient hot-water removal pump operating under conditions corresponding to a suction lift of 30 feet. In its earliest form his condenser had neither a removal nor an injection pump. Water was projected across the condensing chamber in a single jet by the force of atmospheric pressure against the vacuum within. This was called the ejector. An injection pump was added to overcome friction losses, but the result was still relatively inefficient. This condenser, called the "Eductor," has been in general use in England, on the Continent and in this country, but only in smaller installations where efficiency could be sacrificed to simplicity and low original cost.

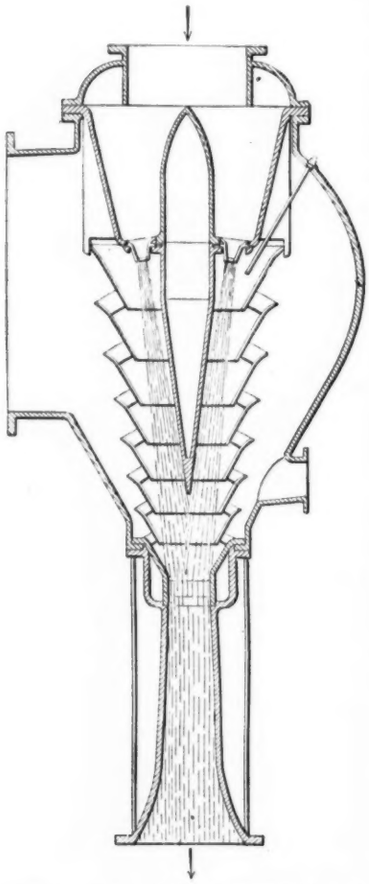


FIG. 1. ORIGINAL DESIGN OF MULTI-JET CONDENSER

The next step was to increase the number of jets in order to obtain greater efficiency of contact between steam and water. This condenser, Fig. 1, was built in small sizes only. Gradually details of construction were changed. The early condenser had the water inlet at the top and a central, torpedo-shaped body dividing the water as shown. This latter has been eliminated and the water brought in at the side, with the steam inlet either at the top or at the side of the condenser to suit either bottom or side outlet turbines. In the earlier installations a standpipe was used to steady the injection pressure. This was an inheritance from reciprocating pumps and is, of course, unnecessary when centrifugal injection pumps are used, as is the case in these days.

The final result is the low-level multi-jet condenser of today. This machine while retaining its inherent simplicity has been so developed that the power required to produce a high vacuum compares more than favorably with low-level condensers operated with separate air- and water-removal pumps.

During the war a number of these condensers were installed with turbo blowers, and the performance records that are given in detail herewith demonstrate that this type of condenser is not only simple and reliable in operation, but is an economical jet condenser for high-vacuum work.

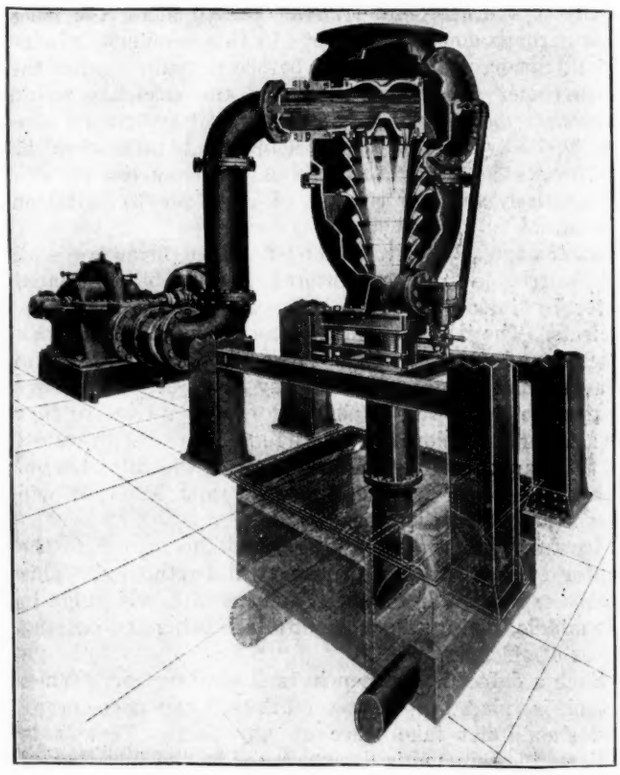


FIG. 2. SHOWING MULTI-JET CONDENSING PLANT WITH INJECTION PUMP; CONDENSER IN CROSS-SECTION

Fig. 2 shows a sectional view of the modern low-level multi-jet condenser. Water is projected through the condenser in multiple jets resembling small fire streams, which meet in a venturi-shaped diffuser, where their kinetic energy is converted into pressure, which ejects

*Engineers with Ingersoll-Rand Co.

water, condensed steam and non-condensible to the atmosphere. Although this type of condenser requires more water than well-designed low-level jet condensers of the usual type or counter-current barometric condensers, no air pump or water-removal pump is needed to maintain vacuums of 28 to 29 inches.

Where the actual quantity of water required is the prime criterion the low-level multi-jet condenser is never used. But the quantity of water is usually important only as it affects the total power consumption. When this is the case the high efficiency of the standard injection pump working with cold water and the saving in power due to the elimination of an air pump result in a relatively low total power requirement for the low-level multi-jet type.

Fig. 3 illustrates the condenser installation at the plant of the Alan Wood Iron and Steel Co., Swedeland, Pa. The condensers, of approximately 3,000 kw. size, are serving two turbine-driven blowers. The entire equipment consists of the condensers and two centrifugal pumps of 14,000 g.p.m. total capacity.

The readings tabulated herewith, taken on the two units when in commercial operation, show the performance of the condensers at different times of the year.

The chart, Fig. 4, shows the relation between vacuum and water temperatures, plotted from winter, spring and summer readings.

At this plant casts are made every four hours, and at these periods a low air delivery is obtained by closing a hand-operated throttle valve which slows down the turbine. This is practically a no-load condition and results in a vacuum throughout the entire turbine casing, back to the high-pressure end and including the shaft packing. Excessive air leakage occurs because the steam pressure on the seal is adjusted for full load.

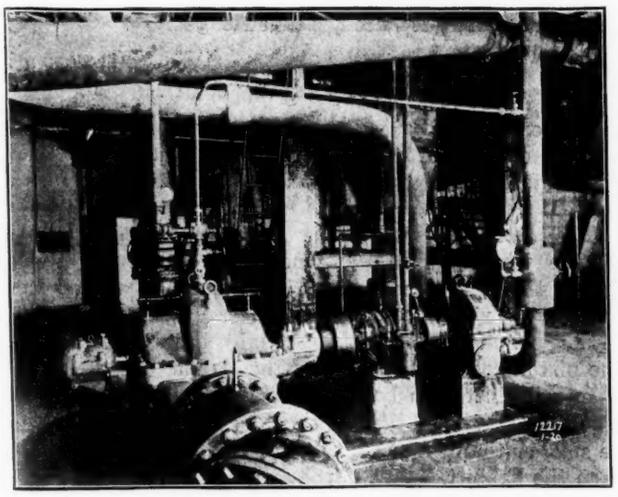


FIG. 3. INJECTION PUMP INSTALLATION AT PLANT OF ALAN WOOD IRON AND STEEL COMPANY

This has been verified in similar plants where the turbine is served by other types of condensers with reciprocating vacuum pumps. The chart, Fig. 6, shows the surprising stability of the low level multi-jet condensers when subjected to this air leakage. The vacuum drops to about 15 in., where it is maintained, and as soon as normal full-load operation is resumed the vacuum is instantly restored. This is possible because the injection of water into this type of condenser is independent of the vacuum, a feature that adds greatly to the reliability of the condenser.

In this connection it may be added that factory tests have recently been made on large units to determine exact air leakage capacity. Air was admitted by standard nozzles such as are used for testing vacuum pumps, and it was found that there is a straight-line law

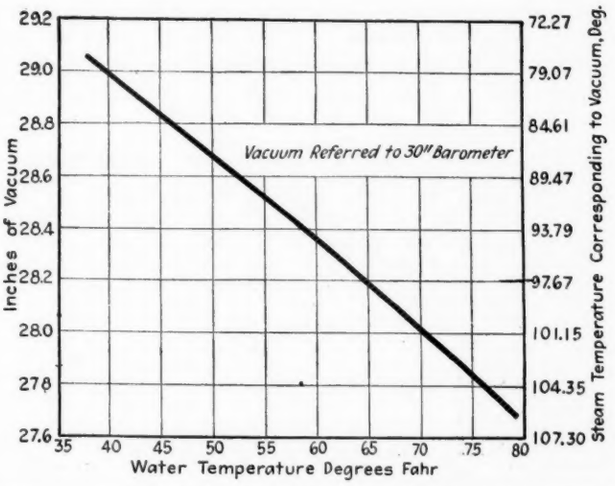


FIG. 4. CHART SHOWING RELATION BETWEEN VACUUM AND WATER TEMPERATURE

between vacuum and amount of air admitted. This fall in vacuum with air leakage seems to be slower than that which occurs in low-level jet condensers with independent vacuum pumps of either water-jet or steam-jet type.

At the Alan Wood plant the condensers are spring-supported and are bolted directly to the turbine exhaust nozzle. This construction eliminates the expansion joint in this installation. The spring supports are simple and are shown in detail in Fig. 2.

The discharge of the two condensers is piped to a single well about thirty feet distant, instead of the

PERFORMANCE OF TWO LOW-LEVEL MULTI-JET CONDENSERS AT PLANT OF ALAN WOOD IRON & STEEL CO.

Unit	Run	Date	Vacuum	Barometer	Injection Water Temperature	G.P.M.
No. 1	1	1–26–20	29.72	30.75	35	7,000
	2	1–27–20	29.30	30.25	38	7,000
	3	1–27–20	29.30	30.25	38	6,730
	4	5–29–30	28.40	30.30	68	7,000 approx.
	5	8–26–20	27.78	30.00	79	7 000 approx.
	6	1–27–20	29.25	30.34	37	6,770
No. 2	7	1–27–20	29.15	30.26	37.5	6,550
	8	1–27–20	29.15	30.26	38	6,440
	9	5–29–20	29.35	30.30	68	7,000 approx.

more common arrangement of an independent well directly under each condenser. A sliding joint at the bottom of the tail pipe takes care of the vertical motion due to expansion and contraction. This movement is very slight and might even be taken up by the flexibility of a long-sweep elbow and short pipe section.

Fig. 2 shows the more common hotwell. It is divided into two chambers by a wall forming a weir. The bottom of the tail pipe is cut at an angle of 45 deg. with the top of this opening on a level with the bottom of the weir. In case of pump failure the maximum quantity of water that can flow back into the condenser is somewhat less than the volume above the level of the bottom of the weir, because some of this water will flow away. This volume is less than that of the con-

denser body, therefore water cannot be drawn into the turbine even though the vacuum breaker should fail to operate. The vacuum breaker consists of a copper float which, in case the water should rise in the condenser body, opens a pilot valve and thus balances the main valve. The continued pressure of the float opens the main valve, admits air to the top of the condenser and breaks the vacuum.

Fig. 5 shows a large condenser for a 5,000-kw. turbine on test at the factory. The factory test consists in pumping the rated quantity of water at rated pressure through the condenser when blanked off; that is, without steam load. Under this condition it must show a vacuum within 0.1 in. of that corresponding to the water temperature. For example, if the water is at 70 deg., which corresponds to a vacuum of 29.26 in., the condenser must show at least 29.16 in. vacuum. This test, together with the factory test of the water pump, insures the performance of the complete condensing plant when put in service.

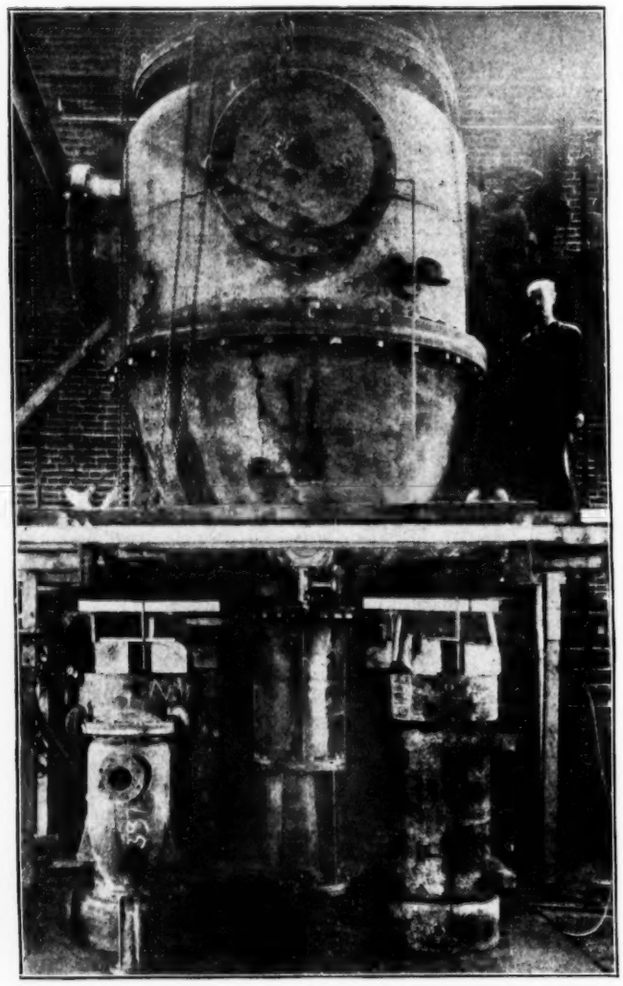


FIG. 5. CONDENSER FOR 5,000-KW. TURBINE ON TEST AT FACTORY

Multi-jet condenser installations of still larger capacity are nearing completion. For example, two large-sized condensers are being installed as a twin arrangement to serve a 7,500-kw. turbine in a large central station. These twin condensers are served by separate injection pumps, a feature that adds greatly to the reliability and flexibility of the installation as a whole. For partial loads or for cold-water operation in the winter time one of the pumps and one of the condensers may be shut down. Under these conditions the injection valve and the valve on the discharge of the condenser are closed.

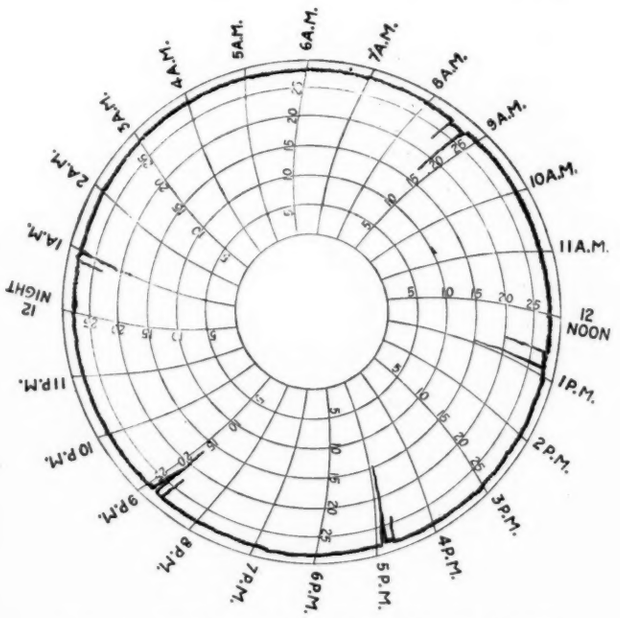


FIG. 6. RECORDING VACUUM GAGE CHART FOR MULTI-JET CONDENSER

The single unit can carry full load at good vacuum o partial load at high vacuum.

The kindness of Mr. Black and the engineers of the Alan Wood Iron and Steel Co. in permitting access to their plant at different times, and for photographs, test data and charts, is hereby acknowledged.

Some Diesel-Engine Pointers

If a crankpin bearing runs warm and scores the pin, a light coating of white lead placed on the pin when reassembling will usually smoothen up the bearing and prevent further heating.

The piston rings should be cleaned every six months. If the top rings are gummed fast, strong lye will loosen them; kerosene and a brass scraper will do the work if the ring is not too tight.

If a piston ring is broken, usually there is a click as the piston reaches the ends of the stroke.

In rebabbitting a bearing clean out all the old metal. The housing should then be tinned. The mandrel should be smaller than the shaft to allow boring to size. Don't peen the babbitt.

When a piston head shows fire-cracks, it can be repaired by welding providing the burned portion along the edges of the fracture does not extend any great distance into the iron. Sewing slight fractures is by far the easiest process.

In replacing a piston, a heavy cord wrapped about the piston ring will compress it so that the piston will enter the cylinder very easily.

In removing piston rings for cleaning, do not put any great stress on the ring or it may snap into pieces.

It is always advisable to round off the upper edge of a piston ring. The lower edge should be square but not sharp.

W. R. Combustion Indicator

The instrument shown in Fig. 1 is a continuous flue-gas analyzer which indicates CO_2 percentages by means of the application of a principle that has resulted in a practical, serviceable and accurate CO_2 or combustion indicator. There are no liquid chemical solutions used in its operation—dry reagent cartridges are supplied by the manufacturer, the Chadburn (Ship) Telegraph Co. of America, Inc., Troy, N. Y., for this purpose. Fig. 2 shows the construction of the indicator. The chemical absorbent in the form of a dry cartridge is placed within a porous vessel concentric with and within a metal cylinder. The upper end of the porous vessel is closed by means of a suitable cover after the cartridge is inserted. The top end of a gage glass connects with the inside of the porous vessel, and the bottom end of this glass connects within a small tank the sole function of which is to contain colored water to supply the gage glass. This colored water is subject to the pressure of the flue gas streaming into the instrument and surrounding the outer surface of the porous vessel. This pressure remains practically constant. The variable pressure occurs within the porous vessel. This is due to the affinity of the dry chemical composition of the cartridge for the CO_2 content of the flue gas which diffuses through the walls of the porous vessel and is absorbed by the dry cartridge, but in this action the pressure within the porous vessel becomes lighter, therefore the colored liquid within the gage glass rises accordingly. It has been found that a definite percentage of CO_2 in the flue gas passing over the porous vessel causes a definite rise of the colored liquid within the gage glass; therefore the water-column indicator is calibrated accordingly and attached to the gage glass so that direct readings of CO_2 percentages are easily seen.

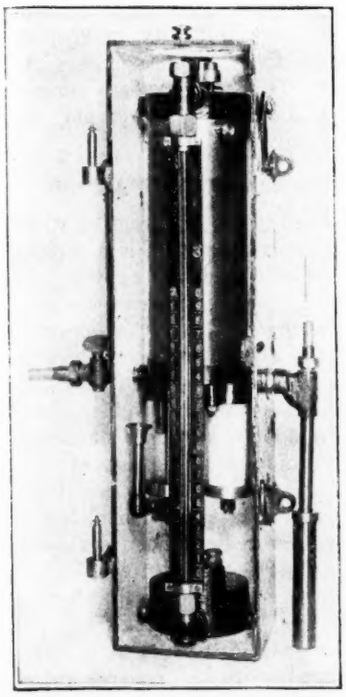


FIG. 1. W. R. COMBUSTION INDICATOR

The instrument should be placed in the boiler room, preferably near the boiler with which it is connected. A special aluminum preliminary filter is provided for the cleaning of the flue gas before it reaches the instrument. As a general rule this filter is placed as near as possible to the point where the flue-gas samples are drawn off; the gas samples, after passing the filter, flow continuously through a pipe line to the instrument itself. This continuous flow of gas to the instrument is maintained by means of a suitable steam aspirator, the steam consumption for this operation being negligible; but where the main flue or chimney has a minimum draft equal to $\frac{3}{4}$ in. water column, a simple venturi arrangement is supplied. This is connected to a suction-pipe line, the other end of which connects with the regulating tap on the side of the instrument and thus provides continuous aspiration without the use of steam or other agent.

The field of usefulness for the instrument is wide, as it is suitable to indicate combustion efficiency obtaining in coal-, oil- or gas-fired furnaces. In its application to the Scotch marine type of boiler it has been proposed to provide a control for each separate oil burner of the boiler so that each separate burner may be independently adjusted with regard to its oil and air supply to give maximum efficiency. When the individual burners are each so adjusted to give a high reading, then samples of the combined flow of the products of combustion from all the burners pass through the instrument, thus indicating the average percentage of CO_2 produced by all the burners in action. In practice this is effected in a very simple way by means of a special multiple-way valve control.

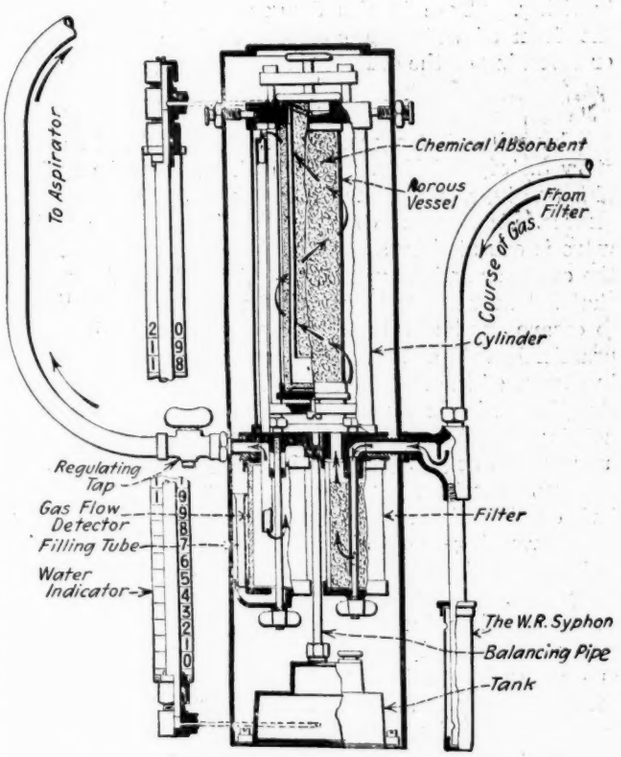


FIG. 2. SHOWING DETAILS OF THE INDICATOR CONNECTIONS

In starting a semi-Diesel engine, the torch should be forced to cause the ignition plug to be heated in the shortest possible time. Slow heating causes the entire cylinder to become hot. Since no cooling water is flowing, the cylinder-head gasket is often ruined by this. The proper temperature of the ignition device, whether it be a bulb or plate or pin, depends on the compression pressure carried. In engines having a pressure of 70 to 90 lb., the bulb must be cherry-red. Higher pressures require lower temperatures; in engines of 160 to 200 lb. compression, the bulb or plate need never be other than black in color. Never flood the cylinder walls with lubricating oil. Use no more than will show a stain on a cigarette paper.

Maintenance of Hydraulic Elevators

By ROLAND L. TULLIS

INSUFFICIENT air in the accumulator of a hydraulic elevator will invariably cause trouble. It will decrease the speed of the car owing to the fact that the air is compressible and acts as a reservoir of reserve power. When the elevator cage starts on its upward flight, it draws water from the accumulator tank faster than the elevator pump can supply it. If there is sufficient air in the accumulator, it will expand and tend to smooth out any sudden fluctuations in pressure caused by the sudden stopping and starting of the car. Remove all the air from the accumulator and the elevator will travel very slowly and will lose its buoyancy and ease of handling. There is also danger of serious trouble in the form of water hammer caused by sudden closing or reversing of the control valve.

A Case of Trouble from Insufficient Air

I have in mind a case of elevator trouble in a six-story factory building. The machine was of the upright plunger type, used for both freight and passenger service. As is usual with freight elevators, the control valve is operated by a hand cable which passes through the car floor and extends the length of the hatchway or shaft. Through negligence all the air had been allowed to escape gradually from the accumulator until it was practically void of air. There was no regular operator in charge of the machine, and the laborers employed in the plant who had occasion to use the elevator knew nothing about handling it and cared less. If they happened to be going up and suddenly decided that they had gone one floor too high, they would give a sudden jerk on the cable and reverse the control valve. Suddenly reversing an elevator while in motion is something to be avoided at all times, still many operators do this every day. In the plant of which I am speaking, this was done when the accumulator was void of air, and water hammer ripped the elevator supply line apart and seriously strained the head on the accumulator, causing it to leak at the seams. To repair the damage cost about five hundred dollars. Thereafter the engineer was careful to keep the proper amount of air in the pressure tank.

An overabundance of air in an hydraulic-elevator system is as bad as an insufficiency. If air gets in the elevator cylinder, there is the liability of the car exceeding the speed limit coming down. The governor may release and set the safety under the car and when the car eventually comes to a stop, the passengers may be badly shaken.

Packing an Elevator

Packing an elevator plunger or piston should be carefully and conscientiously done. The material used should be a good grade of hydraulic packing cut to the proper length and should fit the gland perfectly. Usually, there will be but a slight expansion of the packing under the cold-water pressure; consequently, very little allowance need be made for the expansion of the packing. However, if the plunger is packed too tight, there will be excessive friction and more power will be required to run the car. There will be more wear on the packing and plunger, and the speed of the car will be diminished. On the other hand, if the packing is too loose or improperly fitted, it will leak and the car will have a tendency to creep or sink while standing at the floors; also, the operator will experience difficulty in keeping the cage level with the floor while the passengers are entering or leaving the car. This may cause a serious accident and a consequent damage suit against the company operating the elevator.

Creeping Should Be Carefully Guarded Against

Creeping of the elevator cage in either direction while the operating lever is in its central position is a serious condition and should be carefully guarded against. If the cage refuses to stand at the floors while the passengers are entering or leaving the car, the operator will be compelled to shift the control lever slightly to raise or lower to hold the cage level with the floor. A slight slip of the lever by a nervous or inexperienced operator and the car will suddenly start up or down. If someone happens to be stepping in or out at this moment, it means trouble, and many serious accidents can be attributed to this cause. If space permitted, a number of cases where passengers have been seriously injured and killed in this manner could be cited.

Creeping of an elevator may be due to a number of different causes. Badly leaking plunger packing will cause the trouble; the pilot valve may leak and allow sufficient pressure to pass and move the control valve, which in turn will allow sufficient pressure in the cylinder to move the car; lever or pilot-valve control gear under the car may have slipped. If the pilot valve is set properly and there is no leakage, the car will stand still with the lever in the central position. The pilot valve may be leaking; these are usually all-metal valves machined to fit the casing. The only remedy is a new valve. Cup leathers on control valves may leak and allow pressure to pass, and move the car. Usually, it will be found that the cup leathers are worn until there is a small hole in the lip of the leather. If the leakage is bad, it can be heard by placing the ear to the valve casing when the lever is in a central position. Small pieces of packing from the elevator cylinder may clog the small port-holes that lead from the pilot valve to the control valve. These small pieces will cause the pilot valve to stick; then when the operator pulls on the lever, he is liable to twist the gears under the car, causing no end of trouble. This can be remedied by placing a suitable strainer in the line that connects the pilot with the main valve.

Care of Elevator Cables

The elevator cables are a vital factor in the safe operation of the car. They should be carefully watched and periodically inspected. In most large cities there are qualified city inspectors who periodically examine the elevator and cables and pass on their condition. Cables may be tested for broken wires or strands by holding a soft piece of pine wood against the cable while it is in motion. If any wires are broken, they will snag the wood. Cables should be protected from moisture and properly lubricated by the use of a suitable cable compound. Moisture and consequent rust will destroy a new cable in a short time. Hydraulic-elevator cables are more likely to be subjected to moisture than those

of electric machines, owing to leaky packing, etc., and the use of water as a motive power. All lifting cables should be equipped with equalizers, so that their length may be adjusted and the proper proportion of the load carried by each one.

Treatment of Elevator Water

Water used in the hydraulic-elevator systems should be given more consideration than it usually receives. There is no doubt that much trouble and expense could be avoided by the proper treatment of elevator water, taking into consideration the unnecessary wear on cylinder, valves and packing by the presence of fine grit and impurities held in suspension in the water; also there are the pump cylinders, plunger packing and valves which handle this water continuously. The presence of a small amount of fine grit or other impurities in the water will greatly increase the wear and tear on the machine.

There is a question whether it would be advisable to use chemically pure or distilled water for this service, as it is a well-known fact that water that has been distilled has a corrosive action upon iron or steel. Therefore such water is liable to attack the metal parts of the elevator machinery and fittings with which it comes in contact.

Use of Soaps or Compounds

However, there could be no objection, and it would undoubtedly be beneficial, to use water that has been properly treated in some sort of water softener for this service. If the water is treated properly, all trace of grit and scale-forming and hardening properties will be removed. The same idea will hold true in the treatment of boiler-feed water. In the treatment of water for power-plant purposes it is not the first consideration to get a chemically pure water, but to get a non-pitting, non-corroding and non-foaming water.

In plants where it is impossible to obtain properly treated soft water for elevator service, it is advisable to use some form of elevator soaps or compound which is especially prepared for this purpose. The compound consists of a combination of fat and alkali. The fatty portion of the compound acts as an emulsion and when circulated through the system imparts considerable lubricating value to the cylinder, plunger and packing. If sufficient quantity of the compound is used, most of the mineral impurities in the water will be precipitated to the bottom of the surge tank, where they can be removed at an opportune time, or by the use of a drain pipe at the bottom of the tank.

No More Coal

Power is ever ready and willing to help along a good cause, and if in so doing it can at the same time aid its readers in obtaining a fortune, so much the better. Hence, at the risk of incurring the bitter enmity of our less benevolent and enterprising contemporaries we hasten to divulge the result of an investigation undertaken at the suggestion of a correspondent who sends us a clipping from the advertising columns of a New York evening paper, headed "No More Coal."

It seems almost incredible that under the very shadow —well, anyhow, within shooting distance—of the Engineers' Building there should exist a machine which, according to the inventor, "harnesses gravitation 100 per cent," but such is the astounding fact, and moreover, stock may now be purchased at ten cents a share, par value $100, in the Perpetual Motion, Power, Heat and Light Co., capitalized at $25,000,000. "Blue Sky Law your protection."

We are not quite sure as to the merits of the "Blue Sky Law," and the Legal Editor is on a vacation; but as according to the inventor's statement, "there are already a hundred and twenty stockholders," the injunction, "Investigate at once—act quick before this stock is sold," seems quite in order.

Fig. 1 shows the working (?) model of the "gravitationpower" machine in all its startling simplicity, and Fig. 2 (which looks like the larva of a Jersey mosquito,

FIG. 1. THE INVENTOR AND THE MACHINE

but isn't) represents the "innards," which swing, oscillate or gyrate on a "frictionless bearing" and thus "revolutionize the power of the world."

The inventor states frankly that the present and first (¼-hp.) machine is not quite perfect, and as "gravitation" is obliged to struggle along with water as an operating medium instead of mercury or molten lead in a vacuum, the "perpetual motion" feature is not yet quite obvious to a casual observer, but as only fifteen hundred dollars' worth of mercury (which "runs rivers in Russia") is required, this should be forthcoming at an early date, when "with a few slight changes" we'll see—well, just watch the quotations on public service securities, that's all! Furthermore, when you stop to think that "a machine 10 times as big as the present one will have 279 times the power, 100 times as big, 144,591 times, etc."—Oh, well, what's the use? And no wonder the inventor says, "I urge, request and demand an investigation and an inspection of my machine by the United States Senate, and all or any Engineer, for the benefit of the People."

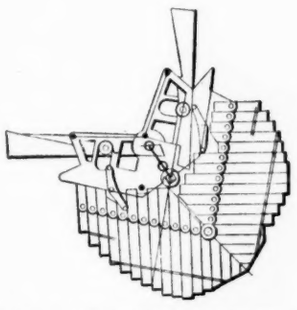
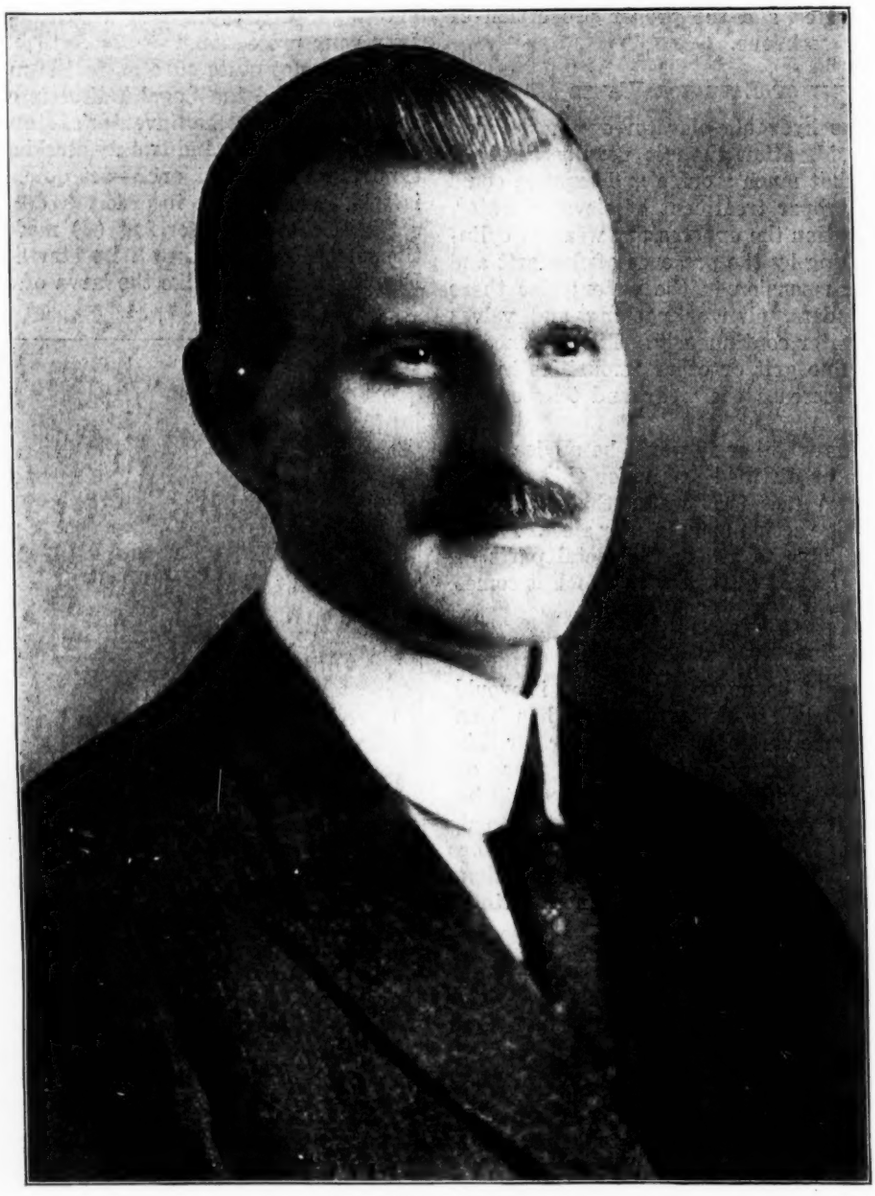


FIG. 2. DIAGRAM OF WORKING (?) PARTS



Edwin S. Carman

New President of the American Society of Mechanical Engineers

The selection of E. S. Carman as president of the A. S. M. E. was a natural one, for Mr. Carman may be regarded as a typical engineer. He was born in Prairie Depot, Ohio, in 1878. When in high school he commenced his engineering studies through special instruction at the Central Manual Training School at Cleveland, Ohio.

His practical experience began in the shops of the Sun Oil Co., of Toledo, where he remained for four years. At the end of that time he took a position with the American Machine and Manufacturing Co., of Cleveland, and in two years was made chief engineer. His work here included the designing of electric traveling and forge-shop cranes and hoists, billet rotators, wire-fence machinery and general rolling-mill equipment. Upon the consolidation in 1908 of this company and the Johnston & Jennings Co., of Cleveland, he became the chief engineer and manager of the new engineering and machine department.

Very soon afterward the Osborn Manufacturing Co., of Cleveland, decided to take up the manufacture of foundry molding-machines, and handed over to Mr. Carman the task of designing and manufacturing this line of machinery. It was a case of starting with nothing but ideas and building up and developing a complete line of apparatus, and Mr. Carman's success at the job is indicated by the fact that in 1913 he became chief engineer, in 1916 director and secretary, and in 1917 works manager of the machine and brush divisions of the Osborn company.

His experience in foundry work has enabled him to write a treatise on "Foundry Molding Machines and Pattern Equipment" and to prepare a number of papers on the subject for the A. S. M. E.

Although Mr. Carman did not become a member of the society until 1917, he made up for lost time by enthusiastic participation in its activities, especially in committee work. An example of his deep interest in engineering affairs is his recent activity as a delegate to the Washington Conference which formed the Federated American Engineering Societies.

EDITORIALS

Direct-Current Motors in Ventilating Service

ARMATURE control of direct-current motor speed is in general considered uneconomical, but this is not always true since the characteristics of the load have a marked influence. If the load requires practically a constant torque at all speeds, then the current will remain constant and the losses due to connecting resistance in series with the armature are approximately proportional to the decrease in speed. At half speed fifty per cent of the energy taken from the line is lost in the armature resistance. However, with a centrifugal fan, where the load varies approximately as the cube of the speed, a somewhat different condition exists.

As pointed out in the article, "Speed Control of Direct Current Motors in Ventilating Service," by W. H. Easton in this issue, the maximum loss occurs at fifty-seven per cent speed reduction and is about nineteen per cent of the motor's total full-load input. Although this loss will amount to considerable if the machine operates for long periods at this speed, nevertheless it is not prohibitive for many applications. When armature control is considered for smaller reduction in speed of fans, the losses are materially reduced and conditions may be such that it is more economical to install a high-speed motor, which, when operating at normal speed, will drive the fan at its maximum, and then obtain lower speeds by armature control.

What percentage of the total period of operation the motor has to operate at the reduced speed will have a marked influence. Therefore the method of working out this problem given by Mr. Easton will be of special interest. In this treatment all three methods of control —armature control, field control and combined armature and field control—are considered. The application of these data will undoubtedly prove useful in checking up installations that are in operation, as well as in proposed installations.

A Warning Against Exaggerated Propaganda

"DISTILLATION of Fuel as Applied to Coal and Lignite" was the subject of a paper read by O. P. Hood, of the United States Bureau of Mines at the annual meeting of the American Society of Mechanical Engineers. In this paper Mr. Hood calls attention to some of the extravagant hopes for a cheap fuel which have arisen in the popular mind in connection with coal distillation and points out how unlikely is the realization of these hopes. His conclusions, in brief, are that the distillation of coal is an expensive process which, while it produces certain valuable products, cannot, and should not be expected to, entirely replace the burning of raw fuel.

This paper points out only one example of the extravagant enthusiasm with which the public welcomes any apparently new idea that is presented in an attractive form. Public interest in any improvement, especially when in connection with fuel conservation, is an extremely valuable asset. The danger lies in leading the laymen to expect too much. When the extravagant promises are not fulfilled, the public becomes disgusted with the whole thing and valuable developments are delayed or sometimes permanently stopped.

The distillation of coal or lignite is so valuable a process that it should not be handicapped. It is not a new idea, as Mr. Hood shows, but its commercial development is still far from complete, and popular disapproval brought about by disapointed hopes would seriously interfere with this development.

Another danger from extravagant popular expectations lies in the direction of too rapid development along unprofitable lines. A certain semi-public institution at one time maintained a small and admittedly inefficient power plant to supply light, power and heat to its buildings. Local popular clamor practically forced the dismantling of the power plant and the purchase of power from a near-by hydro-electric station. The expected saving in fuel was hailed as a great benefit. When the first year was up, however, the records showed that practically as much coal had been burned for heating as had previously been needed for both heat and power, and the additional cost of purchased power had to be met.

The number of similar examples that might be quoted is almost unlimited. It should always be remembered that public opinion is an extremely powerful force. Once set in motion along the wrong lines, it may easily do more harm than good, and the use of exaggerated statements to arouse popular interest is likely to prove a dangerous game.

Practice in Power-Plant Control

WE ALL have much to learn from one another and we can undoubtedly learn much from European countries in the matter of power-plant design, and they from us. In many lines, particularly in control and protection, our tendencies seem to be diametrically opposed to those of French, Swiss and German practice. Whereas we are every day tending toward more elaborate protection and making the operation of our plants more nearly automatic and foolproof, many of the newest plants in western Europe are being laid out on extremely simple lines and their control and signal wiring reduced to a few telephone lines and remote control of the simplest type for the oil switches. Recently, on the other hand, there was put in operation in this country a one-hundred-thousand kilowatt station requiring only three men per shift for its operation. Although this was a hydro-electric station, it nevertheless indicated the tendency in this country in power-plant equipment control.

In the field of lightning protection the divergence is still more marked. Few European plants are equipped with more than condensers and water-jet arresters;

many have only horn-gap arresters; while some plants of over one thousand kilowatts in western Germany and a number of substations on overhead transmission systems have no other protection than choke coils.

The opinion of many European engineers, which was strengthened by our methods of making war, seems to be that we are an amazingly extravagant people in our private life as in our power practice; that, inasmuch as we need tiled bathrooms and hot and cold water to wash in, whereas a small basin and jug of water fill their needs equally well, there is no reason for doubting that their simpler designs will answer their purpose as well as our more elaborate ones.

Which of the two points of view is correct, we are neither of us in a position to decide separately, and discussion, co-operation and comparison of operating statistics will do much to settle the question.

There are several fundamental causes for the divergence of the two practices. First, European plants are almost universally of smaller capacity than ours, and our experience has taught us the disastrous effects of breakdowns in large power circuits. Secondly, distributing networks fed from several interconnected plants are much less frequent, and some of the most involved problems in protection arises from disturbances in such systems. Thirdly, we lay more stress on continuity of service than any European country, and in this respect obtain much better results. Fourthly, the greater scarcity and higher cost of skilled labor in this country is driving us more and more toward automatic operation.

It is interesting to note that several plants in western France clearly show American influence, whereas most eastern plants follow the most rigidly simple lines. No doubt when power systems in Europe grow to the same proportions, and continuity of service is of the same importance as in this country, they, too, will find more elaborate systems of protection and control an absolute necessity.

Oil-Engine Fuel Supply Adequate

THE engineering public has been warned of the shortage that threatens the world unless the consumption of petroleum products is decreased. The public at large cannot be too strongly urged to use every precaution possible toward the lessening of the consumption of all distillate, especially of gasoline. The demand for gasoline has caused the refiner to "cut" more deeply into the crude in the endeavor to supply the market. The consequence is that the price of boiler oil has been increased both because of this reduction in supply and because of the demand for marine use both in the navy and the new shipping board vessels where it has a decided advantage over coal. Coal is essentially the boiler fuel for stationary practice, and economic pressure will probably cause many plants now using fuel oil to return to coal; in fact, in certain sections of the country some power plants have already done so.

Any such problem of fuel-oil shortage should not and does not affect the Diesel or semi-Diesel engine plant. Since the thermal efficiency of these engines is so much superior to that of a steam plant, the oil-engine plant can always secure a fuel supply, being able to offer a higher price than the boiler plant is justified in offering. There will always exist a supply of gas oil and fuel oil, since there is a limit to the maximum percentage of crude that can be converted into light distillate, the fuel oil ranging from 25 per cent to 50 per cent, dependent upon the quality of the crude that is used.

For some time during the summer months tank cars were unobtainable, consequently it was difficult to secure a fuel-oil supply. The same difficulty or greater ones existed as to the coal supply. The present prospective owners of a Diesel or semi-Diesel plant need not worry about the probabilities of a fuel shortage. It is claimed by all who are familiar with the situation that a fuel-oil supply is, and will be for generations, available for the requirements of the oil engine, both stationary and marine.

In comparison with the consumption of other petroleum products the present demand for oil-engine fuel is small, not exceeding six million barrels a year. The fuel-oil output for 1919 totaled over two billion gallons, a large proportion of which was burned under boilers, used in gas works and in industrial processes.

There is no logical reason why the oil-engine owner need ignore the heavier Mexican topped oils. Many Diesels are using the heavy oil with success. The slight operating difficulties can be overcome, and if the domestic fuel-oil price becomes high there should be no hesitancy about purchasing the Mexican oils, which are considerably below the former in price.

As a further source of supply it is well to take cognizance of the immense shale-oil deposits in the West which in time will undoubtedly be placed under development. A conservative estimate places this oil supply at seventy-five billion barrels, or enough to supply the United States for one hundred years if the rate of consumption is maintained at the high rate of 1919. In the distillation of coal there exists a source of oil-engine fuel. In Europe at the present time the light coal-tar oils are successfully used in oil engines.

Trend of The Times

THE newspapers recently reported a meeting "to co-ordinate Americanization work of the American Legion and other patriotic organizations." It was decided at this meeting to work for a congress of delegates from patriotic and civic organizations in all parts of the country.

The November thirtieth issue of *Power* told of the formation of the National Council of State Boards of Engineering Examiners at Chicago on November eighth and ninth. This council was formed to secure co-operation among those who have charge of the licensing of civil engineers in the states that have license laws.

Similarly, the boiler inspectors of states which have adopted the A. S. M. E. Boiler Code are shortly to bring into action the National Board of Boiler Inspectors. Although this board is already in existence, the first meeting has not yet been held; it is expected to take place before long and to be a big success.

Then there is the Federated American Engineering Societies, which is at last a reality. Although hampered by a reactionary spirit among some engineers, vigorous support of other more progressive engineers under the leadership of Herbert Hoover promises a great future for the organization.

Straws show which way the wind blows, and the get-together spirit is assuming the nature of a cyclone.

CORRESPONDENCE

Protective Relays–Reverse-Power Type

Having read the article "Protective Relays—Reverse-Power Type" in the Nov. 2 issue of *Power*, written by Victor H. Todd, there are several things I would like to have the author explain.

The diagram in Fig. 6, reproduced here in Fig. 1, shows single-pole relays without external resistance. I am not very familiar with the Westinghouse type of relay, but I notice that this diagram shows the potential coil of the relay connected to potential transformers which are connected to one leg of the same line from which the current coil is receiving its supply. Diagram Fig. 10, reproduced here in Fig. 2 shows a relay with external resistance which is similar in all respects to a type with which I am better acquainted. The potential element on this relay, as represented in the diagram, is

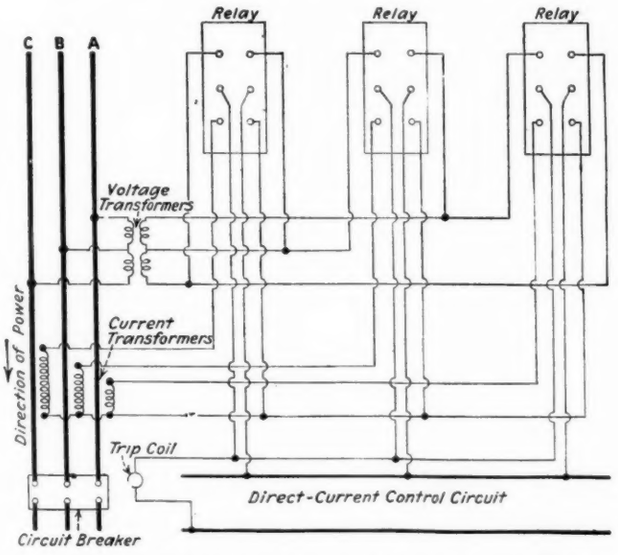


FIG. 1. CONNECTIONS OF RELAYS TO CAUSE THE CURRENT TO LEAD THE VOLTAGE ON NON-INDUCTIVE LOADS

connected to the opposite two wires from which the current coil is receiving its supply.

Also at the bottom of page 691 Mr. Todd speaks of using a single-phase indicating wattmeter to locate the proper connections, and he selected a pair of voltage leads which gave the highest reading. This may apply to diagram Fig. 6, but I fail to see how it applies to diagram Fig. 10, when the power factor is above 87 per cent. In Fig. 10 the current flowing in the potential coil will be in phase with the drop across the resistance, which I should think would make it about 40 deg. out of phase from what it would be if the potential coil was not in series. This would give the maximum torque of the relay with the line current for that element at approximately a 70 per cent lagging power factor.

If we test this element with a single-phase wattmeter using potentials across the terminals which would

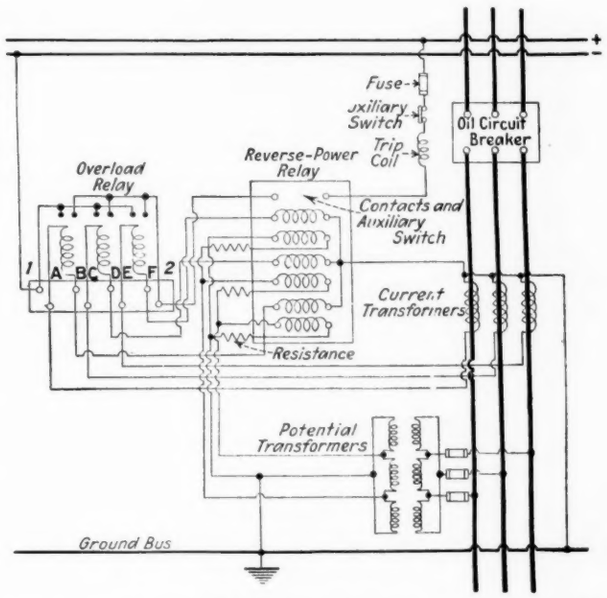


FIG. 2. CONNECTIONS FOR PROTECTING A THREE-PHASE CIRCUIT WHEN THREE-ELEMENT RELAY IS USED

include the resistance and the potential coil, and the power factor was above 87 per cent, I would expect that the wires giving a minimum reading would be the proper connection for this relay. L. A. FITTS.

Turners Falls, Mass.

[The foregoing inquiry was submitted to Mr. Todd and the following explanation received.—EDITOR.]

To discuss the why and wherefore of the connections of reverse-power relays under all possible conditions of electrical abnormalities as viewed from both theoretical and practical standpoints would require a voluminous discourse involving higher mathematics and vector diagrams far beyond the scope of the present discussion. This, however, has been attempted by the engineers of several large electrical companies, who

have arrived at the following conclusion, quoted from the *A.I.E.E. Proceedings* of June 24, 1919, on "Transmission-Line Relay Protection."

In order to secure the operation of the directional relays under bad power-factor conditions, the connections are made so that maximum torque is obtained with lagging power factor. This may be accomplished by several schemes of connections of the potential and

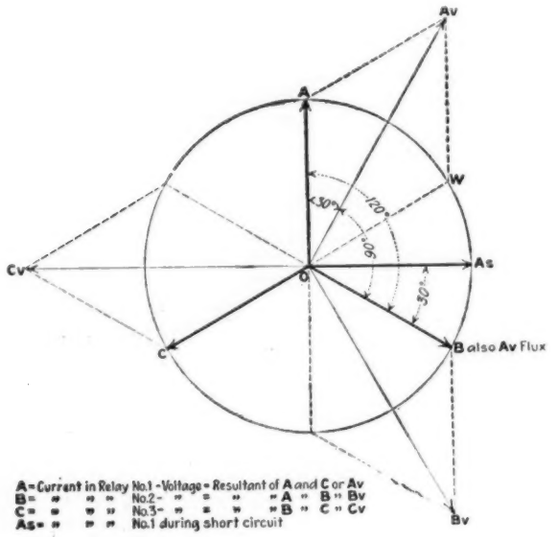

Av
A
W
120°
90°
30°
Cv
As
C
B also Av Flux
Bv
A=Current in Relay No.1 - Voltage = Resultant of A and C or Av
B= " " " No.2 - " = " " A " B " Bv
C= " " " No.3 - " = " " B " C " Cv
As= " " " No.1 during short circuit

FIG. 3. CURRENT AND VOLTAGE RELATION, FIG. 1

current elements, which schemes may not be interchangeable with different types of directional relays.

The difference, then, between Figs. 6 and 10 in the original article on relays in the Nov. 2 issue (Figs. 1 and 2 in Mr. Fitt's letter) is necessary to secure the correct operation of the respective relays. Consider the vectors in Fig. 3; *A*, *B* and *C* represent the currents in the three relays, Fig. 1, while it is evident from the connections of Fig. 1 that the voltage vectors are A_V, B_V and C_V, showing that the current in each of the relays leads its voltage by 30 deg. when the line power factor is 100 per cent. But the internal flux in the potential magnetic circuit lags 90 deg. behind the voltage as represented by line OA_V (flux angle A_VOB). The internal flux produced by the current is in phase with the current and therefore is 120 deg. away from the potential flux, angle *AOB*. Now, should a short-circuit cause the current to lag to a position approaching line OA_S as a limit, or 90 deg., then there is still 30 deg. (angle A_SOB) internal flux displacement between the current and potential fluxes.

In the other arrangement, Fig. 4, the vectors 1, 2 and 3 represent the currents in the relay elements, Fig. 2, but it will be noticed that the current in any element leads its voltage by 90 deg. instead of 30 deg. But, owing to a resistor being placed in series with the potential coil, the internal magnetic flux does not lag 90 deg. behind the impressed voltage, therefore its direction is line *O*2. As before, there is 120 deg. internal flux displacement between the current and voltage magnetic circuits at 100 per cent line power factor, while if the current lags 90 deg. (line $O1_S$), then there is 30 deg. flux displacement as before. There is, therefore, no difference in the internal-flux displacements and consequently the relay torques, in Figs. 1 and 2.

Why is the preference then? The General Electric Co. claims that during a heavy short-circuit on one phase, the voltage drops so low that it will not operate the relay and therefore the connecting of the voltage coils to a phase opposite the current results in always having voltage except should all three conductors be short-circuited simultaneously. The Westinghouse company claims that there is always at least 1 per cent of voltage, which is sufficient to operate a relay, and that the cross-connection results in additional phase-displacment errors which cannot be accurately predetermined. Actual practice, however, has demonstrated that both schemes are very effective in their protection.

Regarding the use of a wattmeter to pick out the proper lines, it is quite evident that the same method cannot be used to pick out lines where the current lags 30 deg. and also those where there is a 90-deg. lag. The method described, however, should have referred specifically to the 30-deg. connection as used by the Westinghouse company. Again referring to Fig. 3, place the current coil in phase with *OA*. We have six possible voltage connections. Connection to OC_V will not give any deflection, while connection to OB_V or OA_V will give equal readings; so this method will not pick out OA_V when the line power factor is 100 per cent. But let line *OA* lag a little; now connection to line OA_V gives the greatest deflection. This is the case until line *OA* lags to position *OW*, which corresponds to

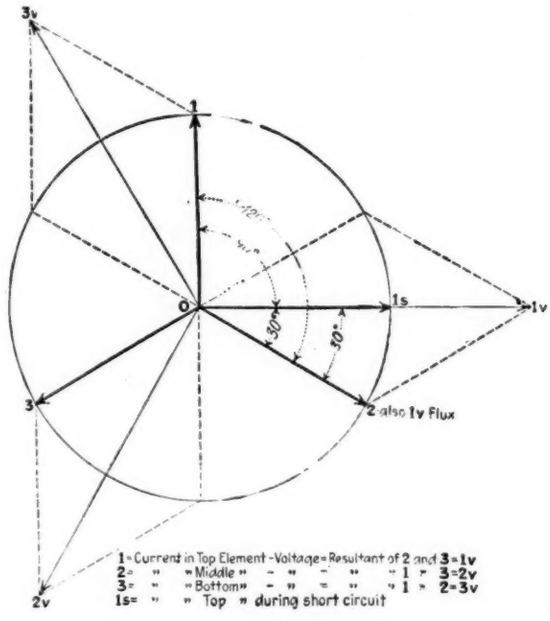


FIG. 4. CURRENT AND VOLTAGE RELATION, FIG. 2

50 per cent line power factor, when connection to either OA_V or OC_V will give equal readings.

If it is desired to use this method for the connection in Fig. 2, then, according to Fig. 4, if the current coil is in phase with line *O*1, and it is desired to pick out line $O1_V$, as this is at right angles to *O*1, we would pick out the line giving zero deflection when the line power factor is 100 per cent. It will also be noticed that the current *O*1 may lead 30 deg. or lag 30 deg. and still line $O1_V$ will give the minimum deflection. This method in this case is applicable when the line power factor falls between 86.6 per cent lead and 86.6 per cent lag.

VICTOR H. TODD.

Orange, N. J.

Design of Hog-Fuel Furnace

The discussion that has been going on in the columns of *Power* recently regarding burning hog fuel has suggested that a description of the furnaces of the boiler of my plant may be of interest. The illustrations show the setting of a 6-ft. diameter by 18-ft. return-tubular boiler equipped with a dutch-oven furnace for burning hog fuel and sawdust. The walls of the setting are of the ordinary kind, 18 in. thick, but the front wall of the oven is 24 in. thick. The brickwork should be well supported with buckstays.

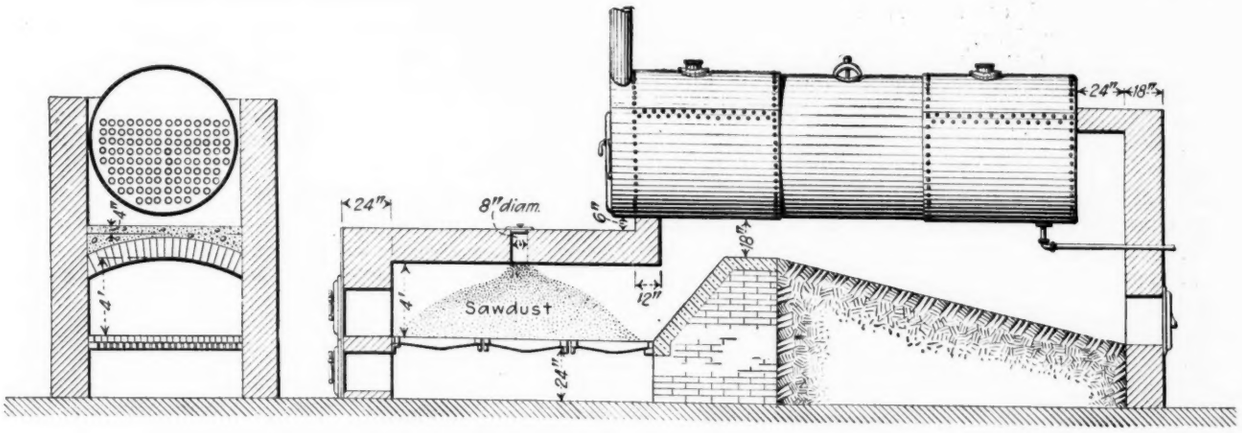
The grates are in three 3-ft. sections, or 9 ft. over all and 6 ft. wide. They are set 4 ft. from the top of the grate to the highest point of the curved arch, and the ashpit is 24 in. deep. An 18-in. space is allowed between the top of the bridge wall and the boiler shell, and the boiler is set so that the dry sheet is 6 in. above the concrete top of the furnace. The dry sheet extending out over the furnace is shown in Fig. 1. The arch should extend back far enough under the dry sheet to support the end walls at the boiler setting.

The fuel hole in the top of the furnace should be placed 6 in. nearer the end of the grate next to the boiler from the center of the grate, as that end of the fire should be the heaviest. This kind of setting will give good results with hog fuel, and it can be used on various types of boilers.

The conveyor should be arranged so that in case the fuel comes too fast for the fire it can be stored for night and Sunday use or deposited at one side of the fireroom. In using coal for fuel a large combustion space behind the bridge wall is required, but with hog or sawdust fuel it is not necessary. I have tried both ways and find that filling in at the rear of the bridge wall gives better results. The fuel should be fed to the furnace steadily as it comes from the hog or saw and allowed to build up in a conical pile, as shown.

When starting the fire, first put a few slabs on the grates before admitting sawdust. If the fires have to be forced, pass wood just through the firedoor. The grate should not be allowed to get plugged with sawdust next to the door, as this will prevent the air from coming up through the grates. Do not use a poker or hoe on the fire, as that will put out the fire around the edges, but just allow the sawdust to feed in from the conveyor or carrier to the feed hole in the top of oven. A fireman will have some difficulty in running a sawdust or hog-fuel fire for a few days if he is not used to it, but he will soon get the knack of it. On opening the rear clean-out door and looking in, a large flame will be seen rolling over the bridge wall if the fire is running properly. A sawdust fire requires a good draft. The ashpit should be cleaned out every day, for if the ashes are allowed to pile up too near the grates there is a danger of burning them. It is a good idea to have a live-stream jet in the stack or to pipe the exhaust from the engine so that it can be turned into a stack in order to force the draft in case the fire gets logy.

Millsite, Vt. G. L. BALDWIN.



END AND SIDE ELEVATION OF FURNACE FOR BURNING HOG FUEL AND SAWDUST

Pounding of Semi-Diesel

I have read the several letters appearing in *Power* offering suggestions as to methods of eliminating the trouble I mentioned in my letter in the issue of Sept. 28. In my original letter, however, I forgot to say that the water we used for cooling was very bad, containing a considerable amount of lime. In taking off the cylinder head, I found the water jacket almost choked with deposits, especially on the top of the cylinder. This lime had greatly impaired the water circulation and caused the engine to overheat. Undoubtedly, the pounding was due to lime deposits; the increased feed of lubrication caused the engine to smoke.

I do not believe the trouble can be attributed to the engine itself; in fact, any engine would do the same under such extreme conditions. We are putting in a cooling tower so that soft water can be used. This was recommended by the manufacturer's service man. So impressed are we with the belief that the semi-Diesel engine is suitable for our work and that the cooling water only was at fault that we have purchased a 75-hp. engine of the same make. A. C. GABLER.

Winside, Neb.

The Air Lift—A Correction

The following corrections should be noted in regard to the article, "The Air Lift," page 818 of the Nov. 23 issue: Formula (1) should read $h_w - h'_w = 2.3 (p_2 - p_1)$. The coefficient of formula (3) should be 0.64 instead of 0.62. The factor 212, in formula (5), should be 6.8.

Wilkinsburg, Pa. A. H. BLAISDELL.

Engineers' License Laws

In the Nov. 6 issue of *Power*, George T. Bromley criticizes W. F. Lockwood's article in the issue of Oct. 19 entitled "Engineers' License Laws." Mr. Lockwood states that he has a Massachusetts license, and I don't think he had any idea that his meaning would be taken as Mr. Bromley has taken it, as he was evidently speaking figuratively. Any engineer knows that it is impossible for an engine to pound so that it can be heard a mile away and that the valves would not be neglected until they got so bad that the engine would not run or speed up so as to cause the flywheel to explode.

I visit power plants every day and meet all kinds of engineers and firemen, good and bad, whether licensed or not. Most engineers keep their engines and engine rooms in good condition, but give little thought to the most important part of a power plant—the boiler house and its equipment.

Few engineers spend much time on the boiler-house equipment. In the estimation of most engineers the boiler is nothing but a kettle with a fire under it for the purpose of making steam to run their engines, and all it requires is someone to throw coal on the fire. They go along from day to day without a thought as to what condition the boiler is in or what the consequences will be should it explode.

In changing a boiler from natural draft to forced draft I asked the engineer, who has a chief's license, if the boiler was clean on the inside. He claimed that it could stand any amount of heat. One week later it was necessary to put in a new sheet on account of scale which was anywhere from $\frac{1}{16}$ to $\frac{1}{2}$ in. thick. It was found later that this engineer had never been inside of this boiler. The fifty or one hundred questions this man had to answer and the engine or other apparatus that he had to adjust before the examining board when procuring his license certainly did not make him an engineer.

How many operating chief engineers go inside of the boilers under their charge to ascertain their condition? Very few, I think. Then how can they know that their boilers are in a condition to withstand the pressure carried. Mr. Bromley speaks of the danger of an engine pounding and the strain that is put on the frame. Can he or anyone in the State House at Boston figure a more destructive force in the pound of an engine than there is in a steam boiler when it is under pressure? I have never heard of an engine leaving its foundation and going up through the roof or through the sides of a building, causing loss of life and destruction of property. I have seen four cases where flywheels have exploded, and in all but one the damage was confined to the engine room and the loss of life was one man. When a flywheel explodes, there is generally a warning given by the engine speeding up, and sometimes the engine can be stopped, or when equipped with automatic stops the accident can be avoided; but when a boiler explodes it gives no warning, and in many cases there are a number of lives lost and a great destruction of property.

I had charge of a 10,000-hp. steam plant a few years ago and had several engineers under me who were all licensed and first-class steam men who could be trusted in any part of the plant, but I was never afraid to take off my white collar and don a pair of overalls and go through my boilers every time they were washed, to make sure that everything was right. I never had to lie awake nights thinking that something might happen to them, or had to answer to the manager at the end of the month for large fuel bills. Besides my boilers and auxiliaries, I had twelve engines ranging from 200 to 900 hp. I kept these engines in the best of condition without neglecting my boilers.

Mr. Lockwood says the employer takes a chance when he calls in an efficiency engineer. I am glad that all the engineers and employers are not of the same opinion as he. If they were, a great many power plants would have had to close their doors in the past year, and it is the efficiency engineer that teaches the operating forces the efficient ways to operate their plants. It may be that Mr. Lockwood is operating his plant at such a high efficiency that he does not need expert advice from these engineers; if so, he is one of a thousand.

I hold a chief engineer's unlimited license in two cities, and I am a strong advocate of the licensing of engineers, but there has never been and never will be an examination or a license that will make a man a first-class engineer, or that will protect the public, the employer or the engineer.

C. J. MILLER.

North Tonawanda, N. Y.

Hotel Plant Experience

The hotel power plant of which I am chief engineer is the only one I have ever seen housed in a separate building and all above ground. It is much more comfortable than a basement plant. In the engine room are two 11 x 10-in. engines direct-connected to 110-volt direct-current generators. These machines have been in use seven years and still have the original carbon brushes. Seven years for brush service is surely a good record.

The heater used for heating service water is thermostatically controlled. The city water pressure is 100 lb. and this is reduced to about 40 lb. for the heaters. A low-pressure reducing valve was in this line, and everybody, from manager down, wondered why it wouldn't reduce; all it did was to slam. A high-pressure valve made everything right. We use live steam for the hot-water service and carry no back pressure on the engines, which I believe saves coal, although there may be a question regarding this.

The heater carries less than five pounds pressure most of the time. The condensation from this heater was trapped to a bucket trap, but all it did was to fill, and as there was no pressure to dump it, it did not dump. I removed the trap and ran the line direct to the house return pump in the boiler room which is a trifle lower than the engine room. In winter we carry from three to five pounds on the heating system. This is the only time we use exhaust steam.

A ten-ton can raw-water ice plant is electrically driven. Water from the ammonia condenser and compressor jackets goes to a boiler-feed heater. When the ice plant was shut down, we had to leave this water running in order to get boiler water. On the other side of the heater was an old balanced float valve. No reducing valve had been used ahead of it and as a result it was "shut," and so this line had been disconnected instead of repairing and putting in a reducing valve. As the condenser water keeps the float in the heater up and the valve closed most of the time, it bypasses through a relief valve into the sewer. I intend to put this water into a tank on the roof for laundry purposes.

Geneva, N. Y. R. A. SUMMERS.

INQUIRIES OF GENERAL INTEREST

Unreliability of Lead Gaskets—What is the objection to the use of sheet lead for gaskets between flanges of a steam lines? J. C.

On account of their softness and the extremely low elasticity of the material, sheet-lead gaskets are very unreliable for making up flanged joints, especially when subjected to variable stresses caused by alternations of expansion and contraction of pipes and fittings.

Belt Drive Less Loss of Power Than Direct Connection—A direct-connected machine is found to require less power when belt-driven than when direct-connected to a motor. Why should this be true? H. A. G.

More power could be required when direct-connected, on account of greater friction due to imperfect alignment or failure of a 'flexible" coupling to entirely compensate the imperfect alignment without increasing the pressure of the journal bearing. Under ordinary circumstances the greater friction would be indicated by higher temperature of the bearings.

Leakage of Cylinder-Head Joint—Since opening the cylinder of an 18 x 36-in. Corliss engine for making repairs to the piston, there is a leakage of steam from the ground joint of the cylinder head. How can the leak be stopped without refinishing the surface? S. L. G.

The leakage undoubtedly results from not replacing the cylinder head just as it was before removal. Carefully clean off the faces of the ground joint, removing all traces of gum or scale with kerosene or gasoline, and prepare a gasket made of uncrumpled manila or drawing paper coated both sides with clean machine oil. Then replace the cylinder head with the paper gasket in the joint, being sure to take up the nuts on the studs by screwing up one after another only a very little at a time.

Preheating Feed Water in Boiler Combustion Chamber—Most of the steam generated in our four 72-in. boilers is used in dye kettles, and we have very little exhaust steam for heating boiler-feed water. Would there not be a saving of coal if we ran a bypass from the feed-water line through pipe coils placed in the boiler combustion chambers and returned the water to the feed lines? J. R. M.

Coils placed in the combustion chambers could be of no advantage except as a makeshift equivalent to increasing boiler capacity by increasing the heating surface. Whatever heat might be absorbed by the feed-water coil would be just that much robbed from the original boiler-heating surfaces. Greater boiler capacity would be obtained only at expense of more fuel, and unless such auxiliary pipe surfaces are designed and constructed to admit of frequent interior and exterior cleaning and receive the same care and attention that should be accorded to water-tube boilers, they soon become inefficient as heating surfaces and are sources of danger from rupture, either by burning out or explosion from becoming clogged with scale and corrosion.

Resistance of Hollow Cylinders to Collapse—What is the formula for computing the pressure required to collapse a cylindrical vessel? J. W. M.

The theoretical formula for resistance to collapse of thin sides of circular cylindrical vessels is the same as for their resistance to an internal pressure, substituting crushing strength of the material in place of tensile strength, viz.,

$$p = \frac{f \times t \times c}{r}$$

in which p is the collapsing pressure, lb. per sq.in.; f, the crushing strength of material, lb. per sq.in. cross section; t, the thickness of the material in inches; c, the percentage of efficiency of the longitudinal joint; or if there is no longitudinal joint the value of c is 1; r, the radius of the hollow cylinder in inches. The formula would be true, however, only for assumption of a perfectly cylindrical shape, and it would have to be assumed also that for external pressure there would be no departure from true cylindrical shape, neither of which conditions could be realized in practice. Actual tests made on tubes and riveted flues have shown that they fail by buckling for considerably less collapsing pressure than they should withstand for perfectly cylindical form maintained to the point of failure.

Size of Wire for Motors—For installation of a 50-hp. 230-volt direct-current motor which will be located 325 ft. away from the switchboard, what size wire should be used for the feeders, the conductors to be run in conduit? M. R. T.

The size of wire will depend upon the allowable voltage drop in the feeder and upon the size that will meet the fire underwriters' requirements. If a 3 per cent drop is allowed in the line, then the volts drop is $230 \times 0.03 = 6.9$. The size of the conductor in circular mils is determined by the formula,

$$circ.\ mil. = \frac{22 \times DI}{E_d}$$

where D equals the length of line one way, I the total current in amperes, and E_d the volts drop in the line. For a 230-volt motor the current per full-load horsepower is approximately 4 amperes; then for 50 hp. the current will be $50 \times 4 = 200$ amperes. The National Board of Fire Underwriters' regulations call for a conductor that will carry 110 per cent of the nameplate current rating of the motor. If in this problem the nameplate current is 200 amperes, then the conductor will have to be of a size to carry 220 amperes, and the size of the conductor would be

$$circ.\ mil. = \frac{20 \times 325 \times 220}{6.9} = 207{,}000$$

The nearest standard size conductor to this value is No. 0000 B. & S., which has a cross-sectional area of 211,600 circ.mil, and is rated at 225 amperes for rubber-covered wire, therefore will meet the fire underwriters' regulation. If the calculations had shown that a smaller wire could be used, it would be necessary to use No. 0000, since this is the smallest size that will meet the underwriters' requirements. Of course the conductor can be made as much larger as desired.

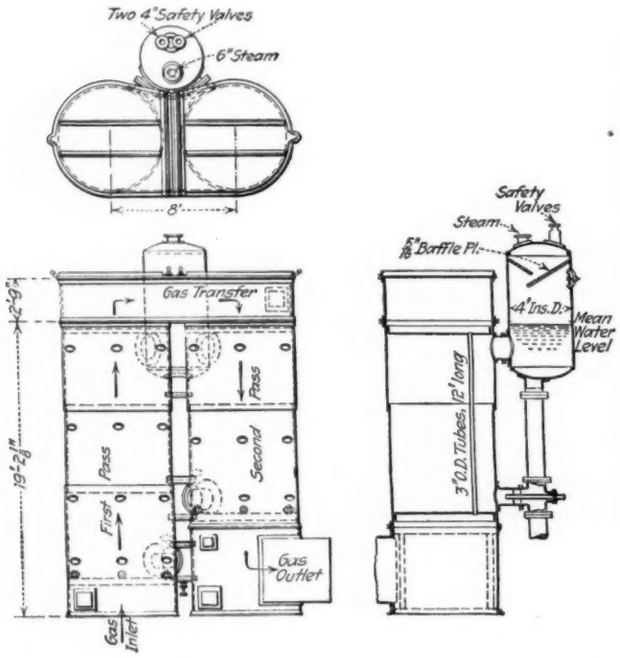
[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Waste-Heat Utilization*

By G. R. McDERMOTT and F. H. WILLCOX

FURNACES employing regeneration or recuperation commonly have left in the gases of combustion leaving the furnace from 35 to 55 per cent of the total heat available in the fuel fired. Non-regenerative furnaces may have as high as 80 per cent. Kilns, oil stills, gas tanks, water-gas sets, etc., all present, on account of the amounts and temperatures of escaping gases of combustion, quantities of waste heat that is not only recoverable but that gives returns that will net from 25 to 75 per cent in one year on the installation cost of the equipment.

In 1910 the first successful application of waste-heat boilers for open-hearth furnaces had been effected in South Chicago, and discoveries made at this plant led to rapid development. Prior to this time waste-heat boilers utilized



BACON WASTE-HEAT BOILER, 82 IN. DIAM., 5,700 SQ.FT. OF SURFACE

waste gases at temperatures of 1,600 deg. F. and higher, as it had been considered impractical to generate steam commercially with gases below this temperature. The accepted deviation from hand-fired types was an increase in the gas-passage area. With the installation previously referred to, C. J. Bacon, formerly steam engineer of the Illinois Steel Co., South Chicago, demonstrated that for gas temperatures under 1,600 deg. F., the gas passages should be decreased and the velocity of the gases increased.

Waste-Heat and Direct-Fired Boilers Compared

Other interesting data were presented, giving the origin of the gases and the amounts of waste gases from a typical 75-ton heat. The temperature of the waste gases from the checkers was 1,300 deg. F. and the total weight of the gases 11,100 lb. At 1,300 deg. F. there were 26,000,000 B.t.u. in the waste gases, as against 60,000,000 B.t.u. in the coal charged; this represented 43 per cent of the total heat charged and was equivalent to 2,400 lb. of coal per hour. Of this 1,270 lb. of the coal equivalent could be recovered per hour from the waste-heat boilers.

Before giving the boiler design required to utilize the foregoing quantity of gas at the given temperatures, the authors reviewed the heat and absorption phenomena obtained in a direct-fired boiler and in the considered case of the waste-heat boiler. Experiments have shown that the heat absorbed by radiation is proportional to the fourth power of the absolute temperature difference between the radiating surfaces. Contrasting a stoker-fired boiler with a combustion temperature of 2,700 deg. F. and waste-heat boilers at 1,300 deg. initial temperature, the absorption by the radiation factor would be:

$$\left(\frac{Tc}{Tw}\right)^4 = (2{,}700 + 460)^4 \;:\; (1{,}300 + 460)^4$$
$$= 3{,}160^4 \;:\; 1{,}760^4 = 10.5 \;:\; 1$$

Thus the absorption by radiation in the case of the direct-fired boiler is over ten times as great as in the waste-heat boiler.

Ordinarily, about 65 per cent of the total evaporation is by radiation and 35 per cent by convection, so that on a 600-hp. boiler, 7,025,000 heat units are absorbed by convection and 13,050,000 heat units by radiation. In the waste-heat boiler but 1,300,000 heat units can be absorbed through radiation, leaving 18,700,000 to be absorbed by convection. Obviously, the rate of heat transfer by convection must be for the waste-heat boiler, 2.75 times greater per square foot of heating surface.

Even this hypothetical ratio does not state the handicap imposed upon waste-heat boiler heat absorption, because the heating surface exposed to the direct heat of the furnace is less than in the case of a direct-fired boiler. Obviously, for a given gas weight, starting in with initial temperatures of 2,700 deg. F. and 1,300 deg. F., respectively, passing through or past identical heating surfaces of the boilers and having identical exit temperatures, the net amount of heat absorbed by convection by the heating surface must be much greater for the waste-heat boiler with an initial temperature of 1,300 deg. The heat transferred by convection per square foot of heating surface of the boiler, therefore, must jump to a figure hitherto considered impracticable. This point of view is not always appreciated. It is not infrequently felt that since a low-temperature waste-heat boiler gives but 70 to 80 per cent of the builders' rating the heat transfer rate is low. Actually, it is very high.

Formulas Used in Making Comparison

An increase in heat-transfer rate is accomplished by an increase in velocity. Consideration of the formulas governing this phenomena will develop the reasons. The rate of heat transfer for either fire-tube or water-tube boilers may be expressed in the form,

$$R = \frac{H}{T - t} = a + b\,\frac{W}{A}$$

Where R = B.t.u. per hour per degree mean temperature difference per square foot tube surface swept by gases:

H = B.t.u. transferred per hour per square foot;

T = Mean temperature of gases (logarithmic);

t = Temperature of tube wall, usually taken as temperature of water in boiler;

a and b = constants;

$\frac{W}{A}$ = Mass velocity, usually expressed as pounds of gas per hour per square foot of area for passage of gases.

In general the constant a is greater for water tubes than for fire tubes of the same size, is greater as the diameter of the tube decreases and is greater as the space between the water tubes decreases. Similarly, constant b is greater for water tubes than for fire tubes, is greater as the diameter of the tube decreases and is greater as the temperature difference between the steam and water increases.

For the constants a and b values may be assigned that are sufficiently accurate for all ordinary engineering applications as they are derived from reliable tests and investigations conducted by boiler companies and independent ob-

*Abstract of Paper read before Western Society of Engineers at Chicago.

servers. The following formulas will serve to illustrate the relative heat-absorbing characteristics of the two types of boilers.

Outside Diameter of Tubes — Inches	Fire Tubes	Water Tubes
1	$R = 3.5 + 0.0013\frac{W}{A}$	
2	$= 2.0 + 0.0008\frac{W}{A}$	
3	$= 1.5 + 0.00065\frac{W}{A}$	
4	$= 1.1 + 0.0005\frac{W}{A}$	$R = 2.0 + 0.0014\frac{W}{A}$

These values apply for 400 deg. F. mean temperature difference, corresponding approximately to waste-heat boiler conditions.

The two most important requisites in proportioning boilers for a given amount and temperature of waste gas are high rate of heat transfer and a low draft loss. Both depend on mass velocity, but the latter varies as the square of the velocity. A boiler arrangement designed for attaining a high transfer rate must be compromised to keep the friction loss within economical limits.

It so happens that whereas the water-tube boiler at a given mass velocity and tube diameter has a higher heat-transfer rate than the fire-tube type, nevertheless the friction loss in the fire-tube boiler is much less. Because of this low friction loss the mass velocity may be raised, and consequently the rate of heat transfer may be so increased as to exceed that obtained in the water-tube type, while keeping the friction loss the same. To illustrate this point, figures are here presented showing that a fire-tube boiler may be designed that will have less than one-half the heating surface of a horizontal cross-baffled water-tube boiler and still give the same performance under the same operating conditions. As a basis for comparison an average size of standard type of water-tube boiler and operating conditions are taken from actual practice.

Results of Tests on Waste-Heat Boilers

Published results of tests on seven waste-heat boilers, all of similar horizontal water-tube type with 4-in. tubes and cross-baffling, show the following averages:

Rate of heat transfer, B.t.u.	5.32
Draft loss, in. water	1.45
Heating surface, sq.ft.	5,030
Weight of gas, lb. per hr.	68,330
Initial temperature, deg. F.	1,330
Stack temperature, deg. F.	470
Boiler horsepower	400

These figures indicate in a general way what may be expected from specially adapted types of water-tube boilers as ordinarily installed and operated. The mass velocity corresponding to the average heat-transfer rate given, as computed by the formula, $R = 2 + 0.0014\frac{W}{A}$, is 2,370 lb. per hour per square foot of passage area.

For the sake of comparison consider some fire-tube boilers so proportioned that the same amount of gas will cause the same loss of draft; namely, 1.45 in. Tube sizes are assumed as 1, 2 and 3 in. diameter, as this selection illustrates the superior advantages of using small tubes. Three cases are worked out as follows:

Type of Boiler	Horizontal Double-Pass Water-Tube	Horizontal Double-Pass Fire-Tube	Single-Pass Fire-Tube	Single-Pass Fire-Tube
Size of tubes, outside dia., in.	4	3	2	1
Number of tubes	...	282	525	1,830
Length of tubes, ft.	...	28	14	5
Heating surface, sq.ft.	5,030	5,700	3,400	1,960
Weight of waste gas, lb. per hr.	68,000	68,000	68,000	68,000
Mass velocity, lb. per sq.ft.	2,370	5,900	8,000	8,500
Rate of heat transfer, B.t.u.	5.32	5.34	8.40	14.60
Draft loss, in. water	1.45	1.45	1.45	1.45
Initial temperature, deg. F.	1,330	1,330	1,330	1,330
Stack temperature, deg. F.	470	470	470	470
Boiler horsepower	400	400	400	400

Inasmuch as the rate of heat transfer at high mass velocity varies almost in proportion to the mass velocity, it is obvious that the number of tubes may be decreased without materially affecting the evaporation. This greatly reduces the first cost, and the only disadvantage is the increase in friction loss. For example, the evaporation obtained in the boiler with 1,830 1-in. tubes, 5 ft. long, may be equally well obtained with only one-half the number of tubes by increasing the length to 5.25 ft., as follows:

Size of tubes, o.d., in.	1
Length of tubes, ft.	5.25
Number of tubes	915
Heating surface, sq.ft.	1,130
Weight of gases, lb. per hr.	68,000
Mass velocity, lb. per sq.ft.	17,000
Rate of heat transfer, B.t.u.	25.5
Draft loss, in. water	6.15
Initial gas temperature, deg. F.	1,330
Stack temperature, deg. F.	470
Boiler horsepower	400

The greater friction loss may be compensated for by increasing the length of tubes so as to obtain sufficient additional evaporation to carry the greater load on the fan.

The point is often raised that tubular boilers are not so efficient as water-tube boilers. This is perfectly natural when only the usual types of tubular boilers and methods of using them are considered. As a matter of fact the heating surface of tubular boilers can be made as effective, or even more so, than that of water-tube boilers. The trouble with the usual fire-tube boiler, especially when used for waste-heat applications, is that the area for the passage of gases is too large and there is not sufficient length of travel for the gases. These objections are, of course, overcome by making a long boiler of small diameter or, what amounts to the same thing, dividing the boiler into two or more passes. The matter of tube size is also a large factor, and if the question of cleaning were not of such real importance the tubes could to great advantage be as small as locomotive tubes, or even smaller. Waste-heat boilers used in Europe in connection with gas engines have tubes of only an inch or so in diameter. By increasing the velocity of gases over the heating surface the rate of heat transmission may be raised to a point as high as or even higher than exists in the case of water-tube boilers. Velocity is usually expressed as weight of gas per hour divided by the area of gas passage in square feet.

Considerations of Design

It is evident that for the same mass velocity the water tube gives the higher rate of heat transmission, but the important point is that the mass velocity in the fire-tube boiler may be much higher without an increase in draft loss. For example, the average of tests on nine waste-heat boiler installations, using cross-baffled water-tube boilers having 4-in. tubes, shows: mass velocity, 2,440; rate of heat transmission, 5.42; draft loss, 2.07. If a two-pass fire-tube boiler with 3-in. tubes were used, the conditions would be: 7,630, 6.45 and 2.07 respectively. It is thus evident that for the same draft loss, the fire-tube boiler may have a higher mass velocity and give a higher rate of heat transfer than a water-tube boiler of the type previously mentioned.

It is frequently assumed that any type of boiler that gives good results when fired with coal or other fuel will likewise be a good one for waste-heat utilization. In most instances, however, this is not the case. There are certain conditions that are more or less characteristic of the operation and construction of industrial furnaces which make it uneconomical and otherwise inadvisable to use standard boilers for such a purpose.

A special boiler known as the Bacon waste-heat boiler, designed to utilize at maximum net economy the heat in waste gases, was described by the authors. The initial installations of this boiler were in conjunction with open-hearth furnaces in steel works where the operating conditions and other limitations interfered with obtaining satisfactory results from standard types of boilers.

To keep the first cost low and still maintain a desired evaporative capacity, the design of the boiler is such as to condense the heating surface into the smallest possible space, which requires that the rate of heat transmission through the heating surface be proportionately high. The three conditions conducive to high heat transfer rates are high velocity of gases, small size of boiler tubes and clean heating surface on both the water and gas sides.

As usually built, the Bacon boiler consists of two vertical cylindrical shells, between the heads of which are rolled and electrically welded a large number of small tubes in a

similar manner to vertical fire-tube boilers. The diameter of tubes is kept as small as permits cleaning, and the length is determined mainly by the space available and the friction loss. The object is to insure that the gases have a long travel at high velocity. In some cases it is found desirable that the average velocity exceed 100 ft. per second for the purpose of preventing dust from lodging and to give a high rate of heat transmission. The waste gases enter the gas box at the bottom of the first pass, whence they pass upward through the tubes and into the transfer flue, which directs the flow downward through the second pass, and in the case of an installation now under construction a third pass, which will act as an economizer.

In some forms of construction of the Bacon boiler a single shell is set horizontally and the two passes are obtained by suitable baffling in the steel-plate gas boxes at the ends of the shell. For application to small furnaces this is a better arrangement than the double vertical shell design.

Boiler-scale trouble is minimized on account of feed water being admitted at the bottom of the second, or "cold," pass. Here it becomes gradually heated and rises to the top of the pass. The water then flows from the second pass through an exterior water-circulating connection to the bottom of the first, or "hot," pass. As but one-third of the heat is utilized in the second pass, where gas temperatures at the bottom are not over 560 deg., the sludge deposited is not hard and may readily be blown off through the several blowoff connections. Forced water circulation on a counter-current principle gives a high rate of heat transfer. Liberal handhole access is provided and blowoff valves are arranged to drain the bottom toube sheets.

As a rule natural draft is not sufficient, because the gases leaving the boilers have been cooled to 450 or 500 deg. in the attempt to recover as much of the heat as possible. On this account and because of the intensity of draft required for operating the industrial furnaces and for drawing the gases through the boiler, it becomes necessary to use induced-draft fans. When properly installed and driven, the fans prove an advantageous accessory from the standpoint of better control of the operation of the heating furnaces, and with correctly selected turbine drive the exhaust steam suffices to heat the boiler-feed water.

Foundations for Machinery

By N. W. Akimoff

In a paper before the American Society of Mechanical Engineers at the annual meeting in New York, N. W. Akimoff gives an interesting explanation of the cause of vibration in machinery and offers a decidedly novel solution of the problem.

In putting in a foundation for an engine or like machine, the underlying motive is to so tie it to the earth that the amplitude of the vibration of the machine will be reduced to zero since the mass of the earth may be, for practical purposes, considered as infinite. Even with a massive foundation the designer frequently places a layer of felt or rubber between the concrete and its base with the idea of avoiding vibration. In this way the advantage that might be gained by tieing the machine to the earth is lost.

It would seem that a rational basis upon which to work is lacking, and the author proceeds to point out a rational theory for foundation or superstructure design. Vibration in machinery is due to one of two causes—it may be the result of unbalancing, or from causes other than unbalancing. The first is easily avoided if care is taken to secure a running balance. Even with a perfectly balanced machine whipping of a light shaft, water in a turbo-generator, etc., may produce extensive vibrations. If these latter exist, then the substructure must be designed to be as free from response to these vibrations as possible.

The author then proceeds to point out that any force may be resolved into six separate motions, about the three axes and along the three axes. A free body is said to possess six degrees of freedom. If a body is locked so that no displacement can take place, all six degrees of freedom are suppressed. By fixing two points in a body, there is the effect of rotation about an axis, and only one degree of freedom exists.

To secure stability, there must be a remoteness of the operating speed from any of the several synchronous speeds at which the frequency of the operative speed would be nearly equal to the frequency of the free oscillation of the system. The number of synchronous speeds depends on the number of degrees of freedom. An absolutely free system, such as with an elastic subfoundation, has six degrees of freedom and six synchronous speeds. Even a massive foundation may have six speeds, since it is more or less free. If these synchronous speeds be controlled to avoid appproaching the machine speed, then vibration would be eliminated.

The author then cites the fact, giving as an example an unbalanced revolving weight mounted on a pendulum suspended at *A*, Fig. 1, that the speed which is synchronous with one degree is no longer synchronous if a second degree of freedom be given by the insertion of a second free point. The oscillations will thus be reduced practically to zero, not by steadying the system by something without it, but by an

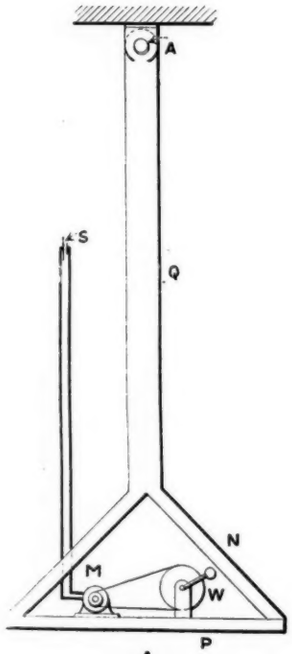


FIG. 1. PENDULUM

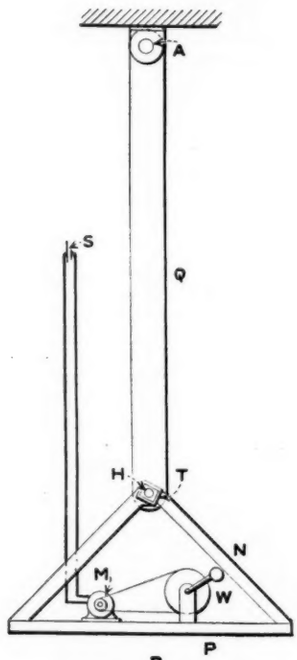


FIG. 2. DESIGN OF TURBINE SUPERSTRUCTURE

adjustment wholly within the vibrating system. Furthermore, the second degree of freedom lies in the plane of the figure and not at right angles to it, as in Fig. 1, *B*.

The Basis of Foundation Design

This, then, will be taken as basis for his further discussion. In contemplating the design of a foundation he states that we should always separate those directions (or axes of instantaneous rotation) about which the system cannot (or at least is not likely to) oscillate from those directions (or instantaneous axes) about which the system is more or less certain to vibrate. We should next select a "steady" point from purely practical considerations, and finally devise such means of controlling the "free periods" of the system as will secure the desired degree of remoteness from synchronism under the actual operative speed. Such means could be springs, exceedingly heavy, and not in the least calculated to allow of any free wabbling of the system. They should also be adjustable so that the desired periods may be readily varied within the wide limits and, in general, structurally arranged to introduce as few changes as possible in the arrangement as a whole.

The author feels that to submit too many particulars as regards the detailed designs of such an arrangement

would certainly defeat the purpose of this paper, which is merely to introduce the broad idea and not any one of the scores of individual designs that might readily suggest themselves to the engineer confronted with the problem of designing a foundation for a given machine. Considering, therefore, only one type of apparatus, a turbo-generator (Fig. 2), we must start out with the selection of the steady point. We will naturally place it as near the steam main as possible (not to the exclusion, of course, of a suitable expansion joint), as under all conditions, should there be a choice of position, preference should be given to that point as far as possible from the center of graivty of the system, so that any static unbalance (whipping, etc.) would be made to act not as a force *upon*, but as a moment *about* that steady point. Such point should actually be made as steady as possible and no trouble should be spared in providing suitable piling or digging down to the solid ground and constructing suitable footings.

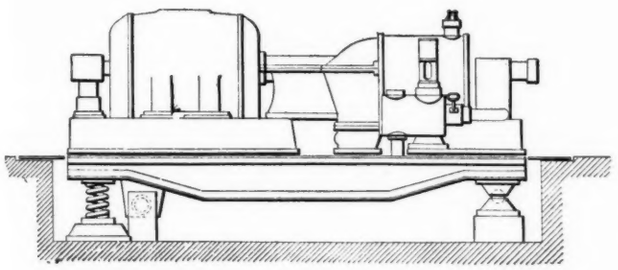


FIG. 2. DESIGN OF TURBINE SUPERSTRUCTURE

The next problem is to design a substructure adapted to receive the bedplate of the apparatus and made stiff enough so as to eliminate any "periods" of its own. This bedplate may be made of structural steel or of reinforced concrete, in which latter case the ends thereof may be made of cast iron. The substructure is supported upon the steady point either by a ball-and-socket arrangement, or is simply bolted at that point to the floorplate underneath by a bolt which need not necessarily be very light, but which must be arranged in a manner to secure the minimum area of actual contact.

Remembering that in apparatus of this sort the tendency to oscillate about the longitudinal axis is always rather negligible, we have practically only two degrees of freedom and only two periods to adjust so as to have them well out of the limits of the operative speed; hence the two sets of springs, one to take care of the period corresponding to oscillation in the vertical plane, the other to control motion in the horizontal plane. It should not be imagined, however, that these springs will necessarily be very light. They will always have considerable stiffness, but their function is that of being the only members that can yield, and the whole situation is controlled by the proper choice of these yielding elements.

The Heat-Insulating Value of Cork and Lith Board

In a paper prepared for the annual meeting of the American Society of Mechanical Engineers by A. A. Potter, J. P. Calderwood, A. J. Mack and L. S. Hobbs, a description was given of the apparatus used and the methods employed in determining the insulating value of cork and lith board. These tests consisted essentially of placing a small cubical box containing a number of electric lights in a refrigerator and measuring the amount of heat conducted through the cork and lith board sides of the cube. Tests were made on both the conductivity and transmission characteristics of each material. From the data secured formulas and tables were prepared. Table I gives the results of the tests on cork board, while Table II gives those of lith board.

The results of these tests are of special interest because of the low value of the external temperature, the average for all tests being approximately 10 deg. F. The mean temperature of the materials tested was approximately 40 deg. F.

The tests indicate that the heat-insulating property of cork board is slightly better than that of lith board. For the samples tested, the lith board has a conductivity approximately 5 per cent greater than that of cork board.

The conductivity and heat transmission of the materials tested increase with the temperature. The change is small, however, between the temperature limits employed in this investigation.

TABLE I. RESULTS OF TESTS ON 3-IN. CORK BOARD, SERIES NO.

Test No.		1C	2C	3C	4C	5C	6C
Temperature at thermocouples, deg. F.	1	36.95	53.69	64.94	79.79	93.20	104.53
	2	36.68	53.97	64.04	78.53	91.84	103.93
	3	33.86	50.90	60.08	75.02	87.80	100.22
	4	8.33	12.65	11.20	14.18	17.96	20.12
	5	4.82	8.06.	5.90	7.52	10.60	12.27
	6	4.86	7.70	5.54	7.07	10.40	11.93
	7	48.36	70.25	85.55	104.18	121.37	133.16
	8	5.66	9.40	8.14	10.27	14.00	16.16
	9	29.86	45.14	53.78	67.64	78.80	90.85
	10	6.56	10.40	9.23	11.30	14.90	17.39
	11	33.86	50.90	61.16	75.38	88.16	100.26
	12	6.09	10.04	8.24	10.94	14.18	16.68
B.t.u. per hr. supplied heater		70.62	100.00	136.26	166.16	197.69	226.56
Average conductivity, B.t.u. per sq.ft. per deg. F. per hr		0.102	0.098	0.105	0.104	0.108	0.109
Average conductivity, B.t.u. per sq.ft. per in. thickness per 24 hr.		7.34	7.06	7.56	7.49	7.78	7.85
Average temp. of cork, deg. F		21.22	32.01	36.50	45.37	53.77	61.10
Transmission,* B.t.u. per sq.ft. per deg. per hr.		0.082	0.084	0.088	0.089	0.093	0.096
Transmission,* B.t.u per sq.ft. per deg. per 24 hr		1.97	1.97	2.11	2.13	2.23	2.30

* Based on temperatures 2 in. from surface. Density of sample, 11.8 lb. per u.ft.

TABLE II. RESULTS OF TESTS ON 3-IN. LITH BOARD, SERIES NO. 2

Test No.		4L	3L	2L	2XL	1L	5L
Temperature at thermocouples, deg. F.	1	42.89	56.84	72.81	72.73	88.93	110.92
	2	42.80	56.66	72.37	72.50	88.16	111.38
	3	40.19	53.06	67.91	67.91	84.79	103.38
	4	11.03	14.00	14.90	15.35	16.34	16.07
	5	6.80	8.24	7.88	8.60	8.24	6.71
	6	6.53	7.88	7.70	8.33	7.79	6.62
	7	57.56	75.20	96.12	95.72	116.60	138.74
	8	8.00	9.92	10.39	10.80	11.39	10.49
	9	37.22	48.56	63.20	63.33	77.18	92.21
	10	8.60	10.69	11.66	11.75	11.75	11.75
	11	41.09	54.50	69.87	69.80	84.92	105.62
	12	8.60	10.54	10.99	11.64	12.20	11.75
B.t.u. per hr. supplied heater		87.85	116.66	153.70	153.98	199.16	249.85
Conductivity, B.t.u. per deg. per sq.ft. per hr. Method 1		.....	.....	0.112	0.118	0.126	0.109
Conductivity, B.t.u. per deg. per sq.ft. per hr. Method 2		0.104	0.107	0.110	0.109	0.107	0.113
Conductivity, B.t.u. per deg. per in. thickness per 24 hr		7.49	7.70	7.89	7.85	7.70	8.06
Transmission,* B.t.u. per sq.ft. per deg. per hr.		.....	.....	0.090	0.090	0.092	0.094
Transmission,* B.t.u. per sq.ft. per deg. per 24 hr.		.....	.....	2.17	2.16	2.21	2.26

* Based on temperatures 2 in. from surface. Density of sample, 10.8 lb. per cu.ft.

The conductivities of the materials as determined in this investigation agree fairly closely with those obtained by other investigators. The United States Bureau of Standards, for example, gives the following values for the conductivity of cork board:

Conductivity, B.t.u. per in. per deg. per sq.ft. per 24 hr	7 4
Density of material, lb. per cu.ft	11 3
Mean temperature of material, deg. F. (25 deg. Cent.)	77.0

And They Claim Oil-Field Boilers Do Not Explode

Bluffton, Nov. 26—Due to a defective flue, the boiler at a drilling well on the Ewing lease of the Ohio Oil Co., east of here, exploded yesterday. The barrel of the boiler was hurled fifty rods from the engine house, passing over the heads of three woodcutters.

The dome and shell of the boiler were blown about 1,500 feet, passing over a clump of trees. The explosion was the most severe in the history of the Bluffton oil field. Loss is estimated at $1,000.—*Toledo News-Bee.*

A.S.M.E. Holds Annual Meeting

Fuels, Railroads, Design and Research Problems Are Among the Many Subjects Considered—Industrial Relations Discussed by President Miller—President-Elect Carman Introduced—1,926 Members Present

ENGINEERS from all parts of the country to the number of 1,926 gathered in New York City recently to take part in the forty-first annual meeting of the American Society of Mechanical Engineers, which took place on Dec. 7, 8, 9 and 10. Transportation was the keynote of the meeting, but numerous papers presented were more directly in *Power's* field, and several of the addresses heard were of great general interest. At the Tuesday evening meeting the incoming president, Edwin S. Carman, was introduced. Mr. Carman has the honor of being the youngest man who has ever achieved the presidency of the A.S.M.E. The most interesting speech of the evening was made by Fred J. Miller, the retiring president.

Industrial Relations and Profiteering

Mr. Miller gave his ideas on industrial relations and the engineer's part in controlling them. He emphasized the thought that is coming to be more and more generally accepted nowadays—that the engineer must increase the effectiveness of labor, not by driving, by oppression or suppression, but by the application of brains in the industrial organization, and the management of men as well as of materials. His influence must be in the direction of constructive adjustment—such an adjustment as will show recognition of property rights as well as human rights.

Of course there are and always have been employers who have been fair to their employees and have been real leaders of men, but in many cases the most profound thought that seems to have been applied to industial problems has led to the conclusion that industrial management consists in hiring as cheaply as possible and driving as hard as possible. The day of that sort of thing is passing and industry is being conducted on a much higher plane of intelligence. We have been hearing frequently about falling off in production per man-hour, and it is true there has been a great deal of that; but the fact remains that many of our industrial establishments have been conducted upon a hire, drive and fire plan. Too often plants are conducted by financiers or others who know little or nothing about industrial matters and are far distant from the locality where the work is carried on. Unfortunately, morale and esprit de corps are not represented by any items on balance sheets, and some of the men at the head of large manufacturing concerns know little or nothing about manufacturing except balance sheets as reported by others who, in turn, know little or nothing about management science.

It is becoming generally recognized that the question of whether an employer shall confer with his men or their representatives upon their request is not simply a dispute within an independent business corporation, but is a matter that concerns the public as well. A corporation is created and exists by authority of the people; they depend upon it for imperative necessities and, consequently, have a right to demand that it be properly conducted.

Usually, where an engineer has acquired enough property to be termed well off, it is the result of services rendered. Mr. Miller compared Corliss and his early practice of selling so many engines upon the basis of a standard share of the saving of fuel for a limited time, with the usual absentee owner of the anthracite coal fields of Pennsylvania who creates no coal, digs and transports no coal, and does nothing except own the ground in which it had been placed ages ago for the benefit of mankind. Some of these owners recently have been doubling and more than doubling their royalties, the State of Pennsylvania helping them to retain their grip by applying taxes to the ridiculously low valuations of their property as unproductive farm land.

Corliss had for a limited time a monopoly of that which he himself had created; yet no man discarded the plain slide-valve engine for the improved Corliss engine except by his own free will. On the other hand, the anthracite coal owners have not produced that which they have monopolized, and yet the public must have coal at any price demanded.

After this address by President Miller the usual presidential reception and dance was given.

Programs of General Interest

The usual committee reports were presented at the business meeting, held Wednesday morning; one, the report of the Committee on Code of Ethics, developed a lively discussion. A code was presented, but was referred back to the committee for improvement. The consensus of opinion seemed to be that the thoughts expressed by the code were admirable; the language used to express these thoughts, however, was very frankly and thoroughly criticized.

Another meeting of general interest was held on Wednesday evening, in memory of one of the society's most distinguished members—Dr. John Alfred Brashear, who died April 8, 1920. Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching, and for years a close personal friend of Dr. Brashear, entertained his hearers with a notable address on the great scientist and his work. The speaker's intimate knowledge of Dr. Brashear's life enabled him to paint a vivid picture of his early struggles against poverty and adversity of all kinds. He told how Dr. Brashear and his wife had built their first telescope in a little shop in back of their home; how for years he had toiled half the night, after his day's work in a rolling mill, to make a still more perfect lens. At the time of his death Dr. Brashear was famed throughout the world as a maker of precise astronomical instruments and had constructed some of the largest glasses in use. Dr. Pritchett gave a number of reminiscences of his friend, and dwelt at length upon the extraordinary kindness of the man, for which he was admired and respected as much as for his scientific achievements.

The Wednesday meeting of the newly formed management section was also somewhat in the nature of a memorial; it was devoted to consideration of the life and work of Henry L. Gantt, a member of the society, who died Nov. 23, 1919. Mr. Gantt is famous for his own efforts and for his work in collaboration with Dr. Frederick W. Taylor toward the elimination of waste in manufacturing processes and the establishment of just relations between employers and employees. Several papers were read, notably one by Walter N. Polakov, who made a very careful analysis of what he termed "Ganttian Philosophy." His paper, entitled "Principles of Industrial Philosophy," was a thorough and favorable study of Mr. Gantt's ideas and methods of securing results.

Fuel Sessions

What proved to be the banner session of the meeting was that on fuel. With an attendance that packed the capacity of the hall the session which was scheduled for Tuesday afternoon outgrew its allotted time and was continued over into Wednesday forenoon, and with a lively discussion still waging was again continued over to Thursday evening.

In his opening paper on the "Fuel Supply of the World," the chairman, Professor Breckenridge, pointed out that fifty years ago the total coal production of the United States was less than one ton per capita. Today it is slightly over six tons. The United States consumes 52 per cent of the coal used each year, and over two-thirds of the world's petroleum production. Moreover, the total coal consumed in tons about equals the estimated population of the world. The tables show the estimated coal reserve, including lignite, of the principal coal-producing countries of the world,

also the annual coal production and one year's fuel requirements of the United States.

ESTIMATED RESERVE COAL AND LIGNITE SUPPLY OF PRINCIPAL COAL PRODUCING COUNTRIES OF THE WORLD

Countries	Supply in Billion Tons	Source of Information
United States	3,427	United States Geological Survey
China	1,500	Sec'y Bituminous Coal Trade Assn.
Great Britain	180	British Royal Commission
Germany	164	Sec'y Bituminous Coal Trade Assn.
Canada	100	Canadian Authorities
Japan	50	Sec'y Bituminous Coal Trade Assn.
Austria-Hungary	30	Sec'y Bituminous Coal Trade Assn.
France	25	Sec'y Bituminous Coal Trade Assn.
Belgium	20	Sec'y Bituminous Coal Trade Assn.
Chile	2	Sec'y Bituminous Coal Trade Assn.

THE WORLD'S PRODUCTION OF COAL FOR A TYPICAL YEAR (1913)

Countries	Millions of Tons (2,000 Lb.)
United States (72 per cent from Pa., W. Va., Ill.)	569
Great Britain	321
Germany	305
Austria-Hungary	59
France	45
Russia	35
Belgium	25
Japan	23
Tota	1,382

ONE YEAR'S FUEL REQUIREMENTS OF THE UNITED STATES AND ITS COAL EQUIVALENT (13,000 B.T.U.)

Kind of Fuel	One Year's Fuel Consumption	Approx. Coal Equivalent (Tons-2,000 Lb.)	Conversion Factors
1. Peat	25 thousand tons	12,500	2 tons = 1 ton coal
2. Natural gas	800 billion cu. ft.	27,000,000	30,000 cu.ft. = 1 ton coal
3. Wood	80 million cords	40,000,000	2 cords = 1 ton coal
4. Water-power	7.5 million developed water horsepower	55,000,000	33% load factor 5 lb. coal per hp.
5. Petroleum	360 million bbl.	100,000,000	3.6 bbl. = 1 ton coal
6. Coal	650 million tons	650,000,000	.....
Total		872,012,500	

According to the speaker the world's production of petroleum for 1920 would be approximately 525,000,000 bbl., of which the United States would produce about two-thirds. The continents, in the order of their wealth in oil, are North America, Asia, South America, Europe, Oceanica and Africa. However, with the oil fields of the United States perhaps 40 per cent exhausted, it is not reasonable to assume that 60 per cent of the world's output will continue to come from wells in the United States. Professor Breckenridge made the following suggestions of how to prevent waste of coal:

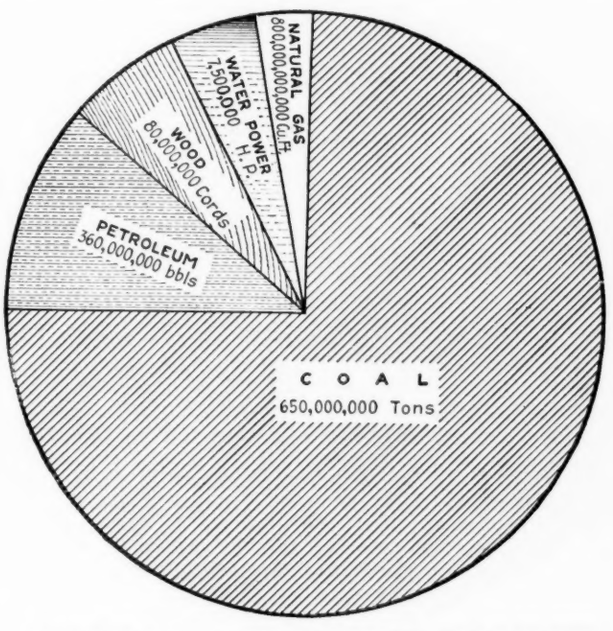
1. Extend as rapidly as possible improved methods of mining, inasmuch as under present conditions one-third the bituminous and one-half the anthracite coal is left in the mines under such conditions that recovery is practically impossible.
2. Extend improved methods of preparation of coal at the mines.
3. Reduce the hazards of coal mining.
4. Operate the mines a maximum number of days each year.
5. Use a large amount of mine waste.
6. Increase the use of byproduct coke ovens and increase the use of domestic coke from the local gas plants.
7. Extend the use of blast-furnace gas for power generation.
8. Extend the use of producer gas and the heavy-oil engine for power generation.
9. Extend water-power development.
10. Extend very generally the best known performance of locomotives. The better locomotives of 1920 use only two-thirds of the coal required twenty years ago to do the same work.
11. Encourage the tendency of the small industrial plant to purchase its power.
12. Furnish homes and public buildings with correct and simple instructions for operating the furnace.
13. Extend the use of coal storage.
14. Encourage electrification.

Fuel Conservation

Following Professor Breckenridge, David Moffat Myers made a plea for fuel conservation and the prevention of waste by the application of well-known engineering principles.[1] A common-sense engineering program of fuel conservation would save over four dollars per capita for every man, woman and child in the United States.

During the war, by the adoption of very simple rules governing methods of operation alone in our power plants and railroads, an annual saving of 25,000,000 tons of coal per year was effected in twenty-five states for an average of less than four months. It was impossible at that time to adopt measures also affecting the design or equipment in connection with the use of fuel. A future program should include such measures. During the war, however, destructive conservation was also largely practiced, which meant the cutting off of coal supply to various industries and uses, with the consequent impoverishment of our industrial and social life. What we should have now is constructive conservation; that is, using fuel without reduction in the output of our manufactured products and without slowing down any of our national or social life. The speaker did not believe that mere financial incentive to stop the unnecessary waste of fuel is strong enough to do the work for the reason that the great bulk of coal and other fuel is consumed in industrial undertakings, where substantial profits are readily available without the trouble of economizing in the application of fuel.

In the speaker's opinion fuel conservation can never be satisfied by development of the central power-plant idea alone. The privately owned plant is essential to economy,



RELATIVE ANNUAL USE OF VARIOUS FUELS IN THE UNITED STATES

and each has its special and appropriate field of service. Neither, as operated today in the average case, fulfills its duty, and the only solution is an adequate plan of co-operation between the two types of plants for the mutual advantage of both in the saving of money and for the advantage of the public in reducing the present enormous and needless waste of coal.

Distillation of Fuel

The distillation of fuels as applied to coke and lignite was discussed by O. P. Hood, chief mechanical engineer of the United States Bureau of Mines. The subject is by no means a new one, said Mr. Hood, but it is receiving growing appreciation by the layman, who is beginning to repeat some of the extravagant statements which he has read regarding it. While there are many advantages in the distillation of fuel it also has its limitations.

[1] An abstract of Mr. Myers' address will appear in an early issue of *Power*.

Distillation of coal may produce coke, gas, pitch and a chain of oils, dyes and medicinals. It must not be supposed, however, that all coal should be made to yield these products, and there will always be much use for raw coal. The processing of coal is necessarily a large enterprise and involves a large expenditure of capital. Even on a large scale the tendency is to emphasize a single product rather than to enter a business involving the marketing of a chain of widely dissimilar products, and in this connection conservation of capital must have some consideration as well as the conservation of raw material. Nevertheless, fields are rapidly developing for the processing of coal. These are made apparent by the increasing cost of coal and the decreasing supply of high-grade fuel.

There is a popular hope that the production of higher valued elements will result in a supply of the residual fixed carbon or coke for the domestic fuel at a reduced price. Coke is one of the chain of products whose relative cost will depend upon market conditions, and so far the coke has been absorbed at a price that leaves little hope for cheap fuel.

Since the amount and quality of the distillation depends largely on the process a variety of results may be obtained. The low-temperature process (not 1,400 deg. F.) is attracting considerable attention on account of the high value of some of the products. The difficulties involved in low-temperature distillation, however, must be equalized by a greater refinement of its products, so that it offers little hope for a cheap fuel. The carbo-coal process is the leading example of this type, but the fuel it yields is a competitor of anthracite and certainly will not be cheap.

The distillation of coal in byproduct coke ovens is already the major process for the production of metallurgical coke. Its byproducts include gas, a tar that may be burned, benzol for motor fuel and ammonium sulphate for fertilizer. The increasing cost of gas oil is causing a tendency toward coal distillation again for city gas. This will insure a supply of coke for domestic heating service.

The lignite areas of the United States offer a field for distillation for the production of domestic solid fuel. In most regions the solid fuel would probably be the main thing sought and the other products wasted. The solid products from lignite distillation, however, must be briquetted for domestic use.

Form Value of Energy

Recognizing that resource energy as the source of power, heat and chemical work is the basis of industrial activity and social advancement, Messrs. C. G. Gilbert and J. E. Pogue presented a paper on "Form Value of Energy in Relation to Its Production, Transportation and Application." The authors pointed out that the conditions under which energy is brought into play in the United States are mainly an inheritance from a period when the character of energy resources was imperfectly known and the technology of energy employment was crudely developed. The production of coal is scattered, unco-ordinated and wasteful. The coal mines carry a variable but large idle capacity, accompanied by an uncertainty of operation, which is at once a menace to the stability of the labor supply. Transportation is the weakest link in our coal supply. Coal forms over a third of the country's freight, and the mining is dependent upon an unbroken movement of coal cars past the mine mouth. The number of cars has never been equal to the full capacity of the developed mines. Again, the present utilization of coal involves a very low recovery of the energy contents. The authors then showed a chart giving the comparative cost per million B.t.u. at unit prices of the various industrial fuels.

Discussion of Fuel Papers

The discussion seemed to emphasize the fact that conservation of heat units does not always mean conservation of dollars, and although much can be done to effect savings through proper design and operation, there are nevertheless bound to be many cases where the greatest conservation of heat units will not be effected until the cost of fuel reaches the point where the saving will more than offset the increased cost necessary to attain it.

Opinion was divided as to the desirability of further governmental supervision in the matter of fuel supply and practice, although it was generally conceded that something should be done to protect the domestic consumer, who cannot protect himself as to quality and price.

Again, one group of speakers was of the opinion that the greatest conservation lay in greater centralization of power to the exclusion of the independent plant. Those taking the opposite view believed that there was a distinct field for the independent plant when properly designed and operated with a view to the use of byproduct steam in heating and industrial service.

Decreased Evaporation Accompanies Poor Quality

John W. Lieb, vice-president of the New York Edison Co., gave some pertinent figures showing the effect of the present coal situation on the public utilities. The latter, he said, used from 50,000,000 to 60,000,000 tons yearly. In 1916 the cost was $3 per ton f.o.b. tidewater, New York, made up of $1.50 freight and $1.50 coal at the mine. Now the freight alone costs more than $3. Moreover, it is at present impossible to get a satisfactory contract that will insure the company of an adequate supply. The operators, he said, were in the habit of reserving a large part of their output to sell as spot coal on the speculative market and were thus unable to meet their contracts for the rest of the coal. It is at present impossible to purchase coal on any quality specifications, and as a result the evaporation per pound of coal has fallen off in spite of the efforts of the operating force. Owing to the poor quality the pounds of coal per kilowatt-hour in the plants of his company have increased 20 per cent over that in 1916, and the cost at the switchboard has gone up from 0.29 to 0.76c. per kw.-hr.

Mr. Lieb strongly urged that the coal operators provide bin storage in order to stabilize their production over short periods when cars were not available. An adequate bin storage, he believed, would not add more than seven cents per ton of coal produced.

Questioned as to the possibilities of shale oil, George Otis Smith, Director of the Geological Survey, stated that this industry was about to be developed in Pennsylvania at the time oil was discovered. The latter was so much cheaper to produce that the shale-oil industry was immediately discontinued. There are great deposits, however, in the West, and these will be available when our present oil supply is nearing exhaustion. Shale oil, however, will be more expensive to produce, and to substitute it at present would be to duplicate much of the manpower of the coal industry.

Discussions on Machinery Foundations

Discussion on N. W. Akimoff's paper, "Foundations for Machinery"[2] was very active, reflecting a somewhat incredulous relief at the prospect of deliverance from the method in use to this day, of blindly adding to the mass of foundations, in the hope of eliminating vibrations. Mr. Hecht emphasized the error of the old system, by bringing out the fact that the earth itself, of practically infinite mass, transmits vibrations to great distances. Mr. Slocum made the statement that if it were not for synchronism, we would never notice the vibrations in machinery. While this is somewhat exaggerated, it is perfectly true that resonance multiplies enormously the phenomenon and should be avoided at all cost. This was illustrated by Morris Deutsch, who told of a seven-story building which vibrated in tune with printing machinery 200 ft. away, to such an extent that a bucket of water placed on the top floor, and filled to within only five inches of the top, would spill over. M. D. Hersey proposed to better the author's scheme by adding a cushion or pad as well as the springs, to further dampen the vibrations and prevent their being transmitted to the foundations. This was in direct contradiction to Akimoff's principle that the machine must on no account be allowed to vibrate separately from its foundations. Perhaps the paper did not sufficiently emphasize this point and the important condition that the springs must be stiff enough to commu-

[2] An abstract of Mr. Akimoff's paper appears on page 994 of this issue.

nicate all vibrations of the machine to its foundations, so that they will vibrate as a whole, though at two separate, synchronous speeds. By adjusting the compression of these springs, these synchronous speeds may be varied so that they will be remote from the range of the operating speeds employed.

The paper by A. A. Potter and others on "The Heat Insulating Properties of Cork and Lith Boards,"[3] was read by Mr. Potter. W. H. Carrier and Prof. A. J. Wood agreed in criticizing the methods employed by the authors and made some suggestions as to a better arrangement of equipment. Prof. H. B. Dickinson, of the Bureau of Standards, Washington, then described methods of testing employed by the bureau, especially the prevention of heat radiation, where objectionable, by use of polished surfaces. Mr. Potter closed for the authors, stating that he, personally, was not quite satisfied with the methods used or the results obtained and hoped that there might be an opportunity in the future of making further tests along the same line, when many of the suggestions offered by those who participated in the discussion would be adopted.

Boiler Tubes Discussed

The paper by Albert E. White on the "Constitution and Properties of Boiler Tubes" was illustrated by lantern slides corresponding with the halftones in the paper showing etched surfaces of boiler-tube samples. Mr. White made a correction in his paper which affects the abstract printed on page 959 of *Power* for Dec. 14. In the 19th line of this abstract the phrase "sodium carbonate" should be changed to "calcium carbonate." F. N. Speller stated his opinion that the ghost lines referred to by the author were not due to phosphorus, as present practice allowed only 0.01 per cent of phosphorus at the outside.

E. B. Powell expressed his appreciation of the kind of work done and emphasized the difficulty mentioned by the author in identifying conditions involving hydrogen embrittlement. A. J. German did not agree with the author in regard to poor material as the cause of bagging of tubes, especially on the bottom row, which he attributed rather to impurities in feed water. The author in his closure emphasized the fact that failure was in many cases due to tubes being under a state of strain, because of careless and ignorant handling, stating that recrystallization was due generally to one or more of four conditions—deformation, time, composition and possibly temperature. He stated also that traces of blowholes were always present, even in material of the best quality. From the experiments made, he deduced that a higher-carbon steel was freer than low-carbon steel from blowholes. G. L. Warden told of an excessive amount of trouble his concern had been experiencing in failures due to poor feed water, adding that if any of the gentlemen present had occasion to use Delaware River water for boilers they could sympathize with him. He stated his belief that the quality of material was improving over war-time conditions, and also that sufficient attention was not being given by the average engineer to deformation as a cause of failure. He also asked if anyone could give information as to increased hydrogen absorption being due to use of oil as a fuel. In reply A. E. Foster stated that he had experienced considerable difficulty in an oil-fired plant in Oklahoma using Arkansas River water, but that conditions had been much improved by treating the water and opening the throat about thirty inches.

Dean E. Foster, in his paper, "The Effect of Fittings on Flow of Fluids Through Pipe Lines,"[4] advanced the new principle that, in computing pressure loss in pipe lines, the fittings may be replaced by a length of straight pipe of equal resistance. He derived simple formulas for water and steam from Konrad Meier's more complex expressions. He also expanded H. V. Carpenter's chart for the flow of steam, to cover both dry, saturated and superheated steam. This chart gave rise to considerable discussion which was entirely beside the subject of the paper, as it emphasized the much debated point that, for the same flow and pressure, superheated steam causes a greater pressure drop in the pipe line than saturated steam; though this is readily admissible if one considers that, at constant pressure and rate of flow, superheating the steam increases its volume, and therefore the velocity of flow through the line.

Defects in Steam Formulas

Robert C. H. Heck started the investigations which are set forth in his paper on "Steam Formulas" with the single purpose of comparing existing experimental data, formulas and tables on the physical properties of steam. His object was more particularly to determine the trend of the different curves at the highest temperatures and pressures attained in experimental work, with a view to extrapolating into the unknown field beyond.

This comparison brought out certain defects in the latest and most universally recognized works on the subject. First, the Marks and Davis tables, published in 1909, though agreeing with experimental data, were thermodynamically inconsistent, the curves presenting marked irregularities between observed values. Second, the Goodenow equations and tables, published in 1914 and 1915, though thermodynamically consistent, did not agree with experimental data. This led Professor Heck to develop an entirely new set of purely theoretical formulas, for which he derived constants from the latest and most reliable experimental work.

The results obtained with these formulas give smooth curves, free from irregularities, over the range covered by experimental work; and, according to the author's contentions, a more rational trend at the limits of this range, thus insuring a fair degree of accuracy in extrapolation.

Professor Marks and Dr. Davis, of Harvard, Dr. Moss of the G. E. Co., and Mr. Buckingham of the Bureau of Standards, agreed that Professor Heck's work was most interesting and valuable, but questioned if there was enough difference between his values and the existing tables to warrant the production of a new set of tables at this time.

Professor Dennis stated that there was urgent need of experimental research on this subject, since common engineering practice had already reached the limits of pressure and temperature thus far investigated.

Professor Heck, in his final discussion, claimed that his tables could be accepted at once as more reliable than the older ones, inasmuch as they agree with the latest experimental work and, on the other hand, give a smoother curve between observed values, and are based on more rational formulas. He thoroughly agreed, however, that further experimental work should be performed.

Faulty Regulation Due to Flywheel Effect

The paper by R. E. Doherty and R. F. Franklin on "Flywheel Design of Synchronous Motor Driven Reciprocating Machines" aroused intense interest. Owing to the many applications of synchronous motors and instances of faulty regulation occasioned by insufficient flywheel effect, the authors considered the subject from the standpoint of the electrical engineer, which is to give ample weight to the wheel, whereas the machine designer seeks to limit the weight to that which is absolutely needed.

In the discussion some comment was made as to the poor characteristics of the synchronous motor from the viewpoint of the machine user. The tendency for the motor to drop out in case of line disturbances seriously affects the operation of such machines as refrigeration compressors. F. L. Fairbanks stated that the sudden stopping of the synchronous motor when fully loaded, threw tremendous stresses on the flywheel. The stresses result not only from the inertia of the wheel but from a reaction within the motor. Mr Fairbanks estimated this electrical reaction or "buck" to be 400 per cent of the full-load torque. He contended that this was sufficient to stop a fully loaded compressor in three seconds. Continuing, he stated that he believe the flywheel weight should be embodied in the motor rotor, and rather doubted the advisability of using synchronous motors with separate flywheels.

Mr. Doherty in reply claimed that the reaction taking place when the motor circuit breaker tripped was only equal to the full load reaction and that no danger of excessive stresses existed.

[3] An abstract of this paper may be found on page 995 of this issue.

[4] An abstract of Mr. Foster's paper will appear in an early issue.

Of the three papers presented at the Textile Section Meeting, the second, by Leo Loeb, on Power Application to Cotton Finishing Plants,"[8] was the only one of signal interest to *Power's* readers. After the paper was read the secretary of the committte read a communication from F. R. Low, which was the only written discussion submitted. In this, and in the oral discussion that followed, some of the author's statements and deductions regarding methods of obtaining thermo-balance were questioned, especially his comparison between engine and turbine operation in its effect on exhaust steam. One point which was emphasized was the great saving in floor space by the use of water-tube boilers instead of fire-tube, and turbines instead of engines. In the author's closure Mr. Loeb answered a question as to the relative operating economy of electrically driven and mechanically driven steam plants by saying that in one case which had come to his notice there had been a saving in fuel consumption of over 30 per cent by electrification.

Power Section

The first meeting of the newly formed power section was held on Friday morning, with John A. Stevens presiding. In the opening paper covering "Policies of Future Power Development," J. P. Jackson made a plea for greater centralization, believing that this will prove the solution of conservation both in fuel and capital. Manufacturing establishments use, he said, 145,000,000 tons of coal per year, with an average of 8.4 lb. per hp.-hr., as compared with 56 million tons used by the central stations at an average of less than 4 lb. per kw.-hr.

The speaker then told of the work being done in England toward centralizing the power supply, the standardization of voltage and frequency and in the elimination of existing plants that are wasteful of fuel. While commending the work in general, he criticized its administration in that it savored too much of governmental control. As a general principle he was opposed to Government interference and urged that public-service commission decisions be governed by law rather than by opinion.

Effect of Load Factor on Cost

In the absence of Colonel Junkersfeld, E. P. Powell read the former's paper on the "Effect of Load Factors on Cost." This paper, which will be abstracted in a later issue of *Power*, took up the relative cost of generation with various load factors, the author pointing out that loss will result if operation is carried on at a higher or lower load factor than that for which the station is designed. In the selection of a site the relation between load factor, supply of fuel, delivery of the finished product, and condensing water were discussed.

High efficiency is obtainable with high boiler pressure, but this entails increased cost which may not be warranted by the load factor.

When a new unit is installed in a power plant it is important to know approximately how soon another will be required. Each succeeding unit is frequently larger than the preceding one, and the increased size is usually accompanied by increased efficiency. The units of highest efficiency usually carry the bulk of the load. However, the extra price paid for the high efficiency sometimes results uneconomically, due to a larger unit being installed earlier than anticipated.

Effect of Size of Plant on Cost

George A. Orrok discussed "The Influence of Size of Plant on Cost," pointing out that large prime movers are more efficient because, between the same temperature limits, leakage and radiation increase only about half as fast as the power and the friction less than one-quarter as fast. Moreover, closer attention is usually paid to operation in the case of large installations.

The author reproduced curves by various authorities, which by comparison showed the advance in economy during the last twenty years due to the use of large units. Of particular interest was a set of curves by R. H. Rice, compiled in 1917, showing the advance in performance of steam-turbine plants from a kilowatt-hour on 30,000 B.t.u. in 1903 to 17,500 B.t.u. in 1916. During this period the gas-engine performance had remained practically stationary at about 20,000 B.t.u. Turbine water rates have decreased from 15 lb. per kw.-hr. for 7,500-kw. units to 12 lb. for 30,000-kw. units.

While the cost of a complete power station depends upon so many local factors that general figures are often of little use, Mr. Orrok nevertheless presented some tentative figures which not only showed the decrease in cost with size but also the general rise during the last few years. In 1914 the cost of a central station varied from $120 per kilowatt for a 5,000-kw. plant to $64 for an 80,000 kw. plant. The estimated best average figures for 1920 are $130 per kilowatt for a 25,000-kw. plant to $108 for $50,000 kw., $93 for 100,000 kw., $85 for 200,000 kw. and $82 for 400,000 kw.

In discussing the preceding papers, W. S. Murray, chairman of the Super-Power Survey, spoke of the advantages of greater interconnection of power systems and told of the increased economies obtained through railway electrification. The steam locomotive, he said, burns five tons of coal and throws three away. Electrification on the New York, New Haven & Hartford R.R. with its Cos Cob power station, which has a relatively low thermal efficiency compared with some of the more recent stations, has shown an economy over the steam locomotive of as high as 2½ to 1.

The speaker was followed by T. K. Thomson, who outlined the plan for utilizing more power at Niagara by building a dam across the river below the rapids. Mr. Thomson endeavored to show that the cost of such a project considered in connection with the power thus made available would be only a fraction of the cost of that now under construction by the Toronto Hydro-Electric Commission known as the Chippawa Power Development.

J. W. Lieb, in discussing Mr. Jackson's paper, expressed the opinion that what the public demands is service at adequate rates and under proper supervision. If we are to have large centralization of power, we must have absolutely reliable service and transmission lines must be supplemented by steam stand-by plants. In this respect one of the benefits of interconnection is that one stand-by plant can be made to serve several companies. Moreover, interconnection should take care of regional and not alone district diversity factors.

Another speaker was Walter N. Palokov, who urged greater consideration of low-temperature distillation of fuel. Carl C. Thomas warned against the granting of too many permits for the development of what might prove small and inefficient water powers, and H. L. Doolittle told of the interconnection of power systems in California, whereby the whole state will be tied together by a 220,000-volt line. He mentioned a plan that has been laid before the state commission as a proposal to promote economy by having savings in operation accrue 50 per cent as a rebate to the consumers, 25 per cent to employees, and 25 per cent to stockholders in the company.

Ampere Centenary Celebrated

Over a hundred prominent men in the electrical field gathered at the little town of Ampere, N. J., on Dec. 4 to honor the memory of the great Frenchman who founded the science of electrodynamics. The town itself was named after the eminent scientist, and in 1908 a tablet was set up there in his honor. There is now hanging above the tablet a bronze wreath which was unveiled at the recent ceremony by the Prince de Bearn, Charge d'Affaires and Councilor of the French Embassy at Washington.

The celebration was conducted under the auspices of the Crocker-Wheeler Co. Its president, Dr. Schuyler S. Wheeler, who acted as chairman of the meeting, characterized Ampere as the discoverer of the electrical law of gravitation. Three speakers—the Prince de Bearn, Dr. M. I. Pupin and Dr. C. O. Mailloux—made interesting addresses in which they described the life and work of Ampere.

[8] An abstract of this paper will be published in an early issue of *Power*.

New Publications

RECIPROCATING ENGINES AND TURBINES. Published by The Travelers Indemnity Co., Hartford, Conn. Paper, 4 x 6 in., 134 pages; illustrated.

This book is published in view of the fact that it is necessary to understand the principles that must be recognized and observed if the reciprocating engine and the steam turbine are to be operated safely and economically. The text matter contains a number of articles that have appeared from time to time in the *Travelers Standard*, but it has been edited, augmented and rearranged to unify the treatment, simplify the language and to bring out the facts with greater clearness. The first main division of the book deals briefly with facts and discusses accident causes, safeguards and safe practice in general. The second main division takes up the discussion on certain theoretical points that should be of interest to the thoughtful engineer, and in dealing with these matters an effort has been made to simplify the language so that it may be understood without any previous study of the subjects. This little volume is compiled in an interesting manner and contains illustrations of a number of the subjects treated, such as flywheel wrecks, safety guards, etc. This booklet is sent free upon application.

MACRAE'S BLUE BOOK FOR 1920. Published by MacRae's Blue Book Co., 18 East Huron St., Chicago. Cloth, 8 x 11 in.; 1,700 pages. Price, $10 postpaid.

This book is a buying guide, or directory of addresses, materials, trade names and prices. The "Catalog Section" consists of 250 pages of advertisements such as ordinarily are to be found in trade journals. The "Address Section" contains in alphabetical order names and addresses of about 30,000 manufacturers. The "Classified Material Section" contains names and addresses of various manufacturers of railway supplies, iron and steel products and building construction material, classified according to the product. The "Trade Name Index" lists a great number of trade names, giving the manufacturer's name and address in each case. This is for use in looking up companies whose products are known as "Agrippa," "Acme," "O. K.," etc. The "Miscellaneous Data Section" consists of tables such as might be needed by men who specify or purchase materials, and deals with a great variety of subjects, including weight per foot of iron bars, wire gages, conversion tables, square roots, etc. The "Standard List Price Section" gives prices of building materials and iron and steel products. A table of discounts is added to save figuring combined discounts such as 20-10-2½, etc. The book should come in handy to purchasing agents and others who need condensed data in a hurry.

Personals

B. W. Latham, previously chief engineer with Cass Gilbert, architect, has taken a position with Murrie & Co., consulting engineers.

Berkeley Williams, until recently chief engineer of the F. H. Lawson Co., Cincinnati, Ohio, is now general manager of the Chatham Manufacturing Co., Middletown, Conn.

C. A. Jackson has left the Pelton Water Wheel Co., of New York, and is now connected with Wm. Cramp & Sons Ship and Engine Building Co. of Philadelphia, Pa., in the hydraulic department.

Otto W. Fisher is now chief engineer for L. O. Koven & Bros., Jersey City, N. J. He was formerly with the Furman-Fisher Corporation.

Grenville A. Harris has resigned his position as chief engineer of the American Steel Export Co. and has opened an office in New York, where he will operate as export engineer, acting as consulting or advisory engineer on export to various manufacturers in this country.

E. C. Morse, whose task was to sell the Government's surplus war stocks, has been presented with the Distinguished Service Medal for performing his duties with "marked ability, energy and judgment." He will end his connection with the Government on Dec. 31.

Society Affairs

The Atlanta Section of the A. S. M. E. will meet in the Carnegie Library on Dec. 28. N. C. Harrison will make an address entitled "Impressions of the Annual Meeting."

The Chief Engineers' Association of Chicago, at the annual election in room 912, Masonic Temple, elected Charles J. Lehn, president; Walter D. Periera, vice president; Clifford Gilmore, recording secretary; W. H. Couch, financial secretary; and Charles Langs, treasurer.

Business Items

The Star Brass Works, of Chicago, announces that beginning Jan. 1 its name will be changed to "Binks Spray Equipment Co." This name will better describe the company's product, which is spray-cooling systems and painting and spraying machinery. The old plant at Chicago has recently been enlarged, and a Pacific Coast office has been established in charge of L. M. Page, Rialto Bldg., San Francisco.

The Erie Ball Engine Co., of Pittsburgh, is now making Ball engines in its large, newly equipped factory at Braddock, Pa. The foundry department still remains at Erie, where these engines were formerly built under the old name of the Ball Engine Co. The new arrangement was made necessary by the lack of adequate manufacturing facilities and will not affect local offices, the personnel of which will remain unchanged.

COAL PRICES

Current mine quotations, with interesting comparisons, are given in the following tabulation:

	Nov. 1919*	Aug. 5 1920	Dec. 2 1920	Dec. 16 1920
Pittsburgh steam	$2.30	$10.00	$5.00	$3.75
Pittsburgh screened gas	2.30	12.00	5.50	4.50
Hocking	2.50	9.00	4.50	3.75
Franklin, Ill.	2.35	6.50	5.00	4.00
Indiana 4th vein	2.35	7.50	4.00	3.25
Eastern Ohio, No. 8	2.35	10.50	5.00	4.00
Fairmont	2.50	13.50	4.75	3.75
Kanawha	2.60	14.00	4.75	4.50
S. E. Kentucky	3.00	10.50	5.25	4.75
Western Kentucky	2.35	5.25	4.25	4.00
Clearfield	2.95	12.00	5.00	4.75
Cambria and Somerset	2.95	13.50	6.00	6.00
New River	2.70	14.00	5.25	5.00
Pocahontas	2.35			

* Government prices.

New Construction

PROPOSED WORK

Mass., Boston — The Selwyn Theater Corp., 229 West 42nd St., New York City, is having plans prepared for a theater here, including a steam heating system. About $500,000. H. W. Crane, 160 North Ashland St., Chicago, Ill., Archt.

Mass., Danvers — C. V. Burgess, Archt., 23 Central Ave., Lynn, is preparing plans for a 2 story, 55 x 120 ft. cold storage plant, here. A refrigeration system will be installed in same. About $75,000. Owner's name withheld.

Mass., New Bedford—The Bd. Educ. received lowest bid for two 2 story, 170 x 250 ft. schools on Mt. Pleasant and Rochambeau Sts., respectively, from J. W. Bishop & Co., 109 Foster St., Worcester, at $638,000 each. A steam heating system will be installed in same.

Mass., Oxford—A. G. Stanhope, 340 Main St., Worcester, plans to build a 2 story, 75 x 100 ft. cold storage plant, here. About $40,000. Archt. not selected.

Mass., Worcester — The Bd. of Library Directors plans to build a library. About $1,000,000. Archt. not selected.

Conn., Meriden — The Conn. School for Boys, Colony St., plans to build a new central heating plant. Archt. not selected.

N. Y., Brooklyn—The Dept. of Educ., 500 Park Ave., New York City, is having plans prepared for a school including a steam heating system on 4th Ave., here. About $650,000. C. B. J. Snyder, 28th floor, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Dannemora—Dr. J. R. Ross, Medical Supt., Dannemora State Hospital, will receive bids until Jan. 5 for the installation of fan, motor, heaters, etc. in Ward Building D of the northwest wing of the Dannemora Hospital. L. F. Pilcher, Capitol, Albany, State Archt.

N. Y., Long Island City—The Dept. of Educ., 500 Park Ave., New York City, will soon receive bids for the installation of a heating and ventilating system in the Bryant High School, here. Former bids rejected.

N. Y., New York—The Dept. of Pub. Welfare, Municipal Bldg., will receive bids until Dec. 24 for a refrigerating plant and the installation of refrigerating and ice making equipment at the Metropolitan Hospital District, Blackwell's Island.

N. J., Atlantic City—The Elks' Lodge, C. Bacharach, Chn., 108 St. Charles Place, plans to build an Elks' Home. About $1,000,000.

N. J., Summit—The Bd. Educ. is having plans prepared for a 4 story school. About $500,000. Guilbert & Betelle, 2 Lombardi St., Newark, Archts.

Pa., Philadelphia — The Selwyn Theater Corp., 229 West 42nd St., New York City, is having plans prepared for a theater here, including a steam heating system. About $500,000. H. W. Crane, 160 North Ashland St., Chicago, Ill., Archt.

Pa., York — Jacob and Isaac Silverman, 1512 11th Ave., Altoona, and Nathan Appell, York, plans to build a 4 story theater including a steam heating system. About $500,000. H. C. Hodgens, 130 South 15th St., Philadelphia, Pa., Archts.

Md., Baltimore — The Union Protestant Infirmary, Division and McMechen Sts., is having plans prepared for a 6 story hospital including a steam heating system at Guilford Ave. and 33rd St. J. E. Sperry, 409 Calvert Bldg., Archt.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., has asked Congress for $180,000 for improvements to the central power plant at the Mare Island navy yard, Cal., and $50,000 for the central power plant at the Cavite naval station, Phillipine Islands.

Va., Fort Story—The United States Engineer, Custom House, Norfolk, will receive bids until Dec. 29 for furnishing material and labor for the installation of a steam heating system in the office-storehouse building, here.

Va., Richmond — Mercer & Tretten, 218 North 9th St., are in the market for one air compressor, gasoline pump and gasoline tank.

Fla., Jacksonville—The City Commission has approved of $2,000,000 bonds for remodeling old cotton warehouse into cold storage plant, build new cotton warehouse and pier, etc.

Fla., Oketchobee—W. W. Dunnicliff, City Clk., will receive bids until Jan. 18 for one engine and pump complete, capable of 350 g.p.m., against a total head of 140 ft., approximately 65 lbs. pressure.

Miss., Jackson—The State Bond Improvement Commission, here, plans to spend $600,000 for repairing old power plants and building new plants at the various state institutions. T. C. Link, care of the Commission, Archt.

La., New Orleans—H. M. Janette, Room 712, Hennen Bldg., is in the market for one 120-hp. Semi-Diesel Skandia marine engine, new or used.

O., Cleveland — The American Steel & Wire Co., c/o H. R. Klepinger, Western Reserve Bldg., had plans prepared for a 1 story, 53 x 134 ft. boiler house at East 40th St. and Lakeside Ave. About $75,000.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., will receive bids about Feb. 15 for heating plant including two 250-hp. boilers for the proposed new school at Diana and Darley Aves. About $100,000. W. R. McCormack, above address, Engr.

O., Cleveland—M. Makof, 3533 Woodland Ave., plans to build a 15 story, 50 x 130 ft. office and theater building including a steam heating system at 1882 East 9th St. About $2,000,000. Archt. not selected.

O., Cleveland—The Mall Motor Co., M. Rohrheimer, Pres., 632 Superior Ave., has purchased a site for a 2 story, 120 x 160 ft. garage incluuding a steam heating system. About $250,000. Christian, Schwartzenberg & Gaede, 1900 Euclid Ave., Archts.

O., Conneaut—The Bd. Educ. had preliminary plans prepared for a 2 story, 200 x 250 ft. high school on Watson St. About $350,000. H. M. McCullough, Ferguson Bldg., Pittsburgh, Pa., Archt.

O., Steubenville—G. Shofer, 1103 Chapline St., Wheeling, W. Va., has purchased a site here, for 3 or 4 story theater. About $300,000.

O., Youngstown — The Bd. Educ., S. R. Creps, Dir. of Schools, 14 Wood St., will soon award the contract for a heating and ventilating system for a 44 room unit at the Hayden High School. Plans allow for an additional unit of the same size to be built later. C. F. Owsley, 1301 Mahoning Bank Bldg., Mahoning, Engr.

Ind., Hammond—The Bd. Educ. plans to build a 2 story, 100 x 150 ft. school including a steam heating system. About $400,000. J. T. Hutton & Son, Archts.

Ind., Indianapolis—The Bd. of Works is having plans prepared for a 3 story, 88 x 175 ft. hospital including a steam heating system on Margaret St. About $400,000. W. E. Russ, 313 North Pennsylvania St., Archt.

Mich., Detroit — The Selwyn Theater Corp., 229 West 42nd St., New York City, is having plans prepared for a theater here, including a steam heating system. About $500,000. H. W. Crane, 160 North Ashland St., Chicago, Ill., Archt.

Mich., Detroit—The Palestine Assn., 510 Fort St., plans to build a 10 story, 150 x 180 ft. lodge house including a steam heating system on Charlotte St. About $2,000,000. A. E. Harley, c/o Committee of Architects, 2631 Woodward Ave., Archt.

Mich., Lansing—The Michigan State Industrial School for Boys, East Lansing St., plans to build 36 institution buildings including a power plant.

Ill., Chicago—The Chicago Telephone Co., 212 Washington St., is receiving bids for a 3 story, 100 x 150 ft. telephone exchange building including a steam heating system at 44th and Drexel Sts. About $250,000. Holabird & Roche, 104 South Michigan Blvd., Archts.

Ill., Chicago—The Hilton Co., Inc., 793 Broad St., Newark, N. J. plans to build an office building here. Cost to exceed $1,000,000.

Ill., Chicago—The North Beach Hotel Co., c/o J. A. Armstrong, 127 North Dearborn St., will soon award the contract for an 8 story, 100 x 170 ft. hotel including a steam heating system. About $1,000,000.

Ill., Chicago—The Union Liberty Co., c/o W. W. Ahlschlager, Archt., 65 East Huron St., will soon award the contract for a 15 story, 60 x 80 ft. office building including a high pressure steam plant. About $400,000.

Wis., Janesville—The Bd. Educ. is having plans prepared for the superstructure of a 3 story, 180 x 200 ft. high school. About $500,000. Van Ryn & De Gellike, Caswell Blk., Milwaukee, Archts.

Wis., Milwaukee—The Civic Comn., c/o Mayor Hoan, City Hall, is arranging to finance the building of a memorial building at 8th and Cedar Sts. About $1,500,000. Archt. not selected.

Wis., Two Rivers — The Bd. Educ. had plans prepared and will receive bids about Jan. 1 for a 3 story, 96 x 110 ft. high school including a steam heating system. About $400,000. J. D. Chubb, 109 North Dearborn St., Chicago, Ill., Archt.

Iowa, Davenport — The Odd Fellows' Lodge, 1420 4th St., plans to build a 3 or 4 story lodge hall including a steam heating system at 6th and Main Sts. About $350,000. Archt. not announced.

Iowa, Fayette—The Board of Trustees of the Upper Iowa University plans to raise $1,000,000 for campus buildings. Archt. not announced.

Iowa, Fort Dodge—Lutheran Congregations, c/o Rev. J. M. Herbst, Webster City, plan to build a 3 or 4 story hopsital, here, including a steam heating system. About $450,000. Archt. not announced.

Iowa, Shelby — The Bd. Educ., M. E. Clapp, Pres., received bids for a 2 story high school including a steam heating system from J. E. Wakefield Co., 750 Brandeis Theater Bldg., Omaha, Neb., $224,000; H. Neuman Co., 519 Hubbell Bldg., Des Moines, Iowa, $213,752; J. F. Cobler, Carroll, Iowa, $229,131.

Iowa, Washington — The Washington Hotel Co., J. M. Wilson, Pres., is having plans prepared for a 4 story, 60 x 120 ft. hotel including a steam heating system. About $350,000. C. A. Dieman & Co., 408 Granby Bldg., Cedar Rapids, Archt.

Minn., Albert Lea—C. G. and R. G. Lang plan to build a 3 story canning plant including a 30 x 30 ft. boiler room. Archt. not announced.

Minn., Minneapolis — The Civic Music League, F. J. Mueller, Pres., 2818 Oakland Ave., plans to build a 10 story Auditorium building including a steam heating system. Archt. not selected.

Minn., Minneapolis—The Orpheum Theater Corp., M. Beck, Mgr., 190 North State St., Chicago, Ill., rejected bids and is revising plans for a 3 story, 115 x 182 ft. theater here, including a steam heating system. About $600,000. Noted Feb. 16.

Kan., Coffeyville—The Chamber of Commerce will receive bids until about March 1 for a 5 story, 100 x 140 ft. hotel. About $300,000. Shepard & Wiser, Long Bldg., Kansas City, Mo., Archts.

Kan., Wichita—G. Theis, Jr., Schweitzer Bldg., plans to build a 14 story, 150 x 150 ft. office building at 113 North Lawrence St. Archt. and Engr. not selected.

Neb., Milford—The Milford Electric Light Plant is having plans prepared for additions and improvements including the installation of a generator, steam plant and a water wheel. Koenig, Hollister & Co., Lincoln, Engrs.

Wyo., Douglas—The city plans an election Dec. 28 to vote on $85,000 bonds for extension to the water system including a pumping plant. Prince, Dixon Engr. Co., Omaha, Neb., Engr.

Tex., Jewett—J. A. Dean and W. N. Martin plan to rebuild their electric light plant recently destroyed by fire.

Tex., San Antonio—A. B. Ayres, Archt., Bedell Bldg., is preparing plans and will receive bids until about Jan. 15 for a 4 story addition to hospital including a steam heating system on Houston St. About $400,000. Owner's name withheld.

Tex., Sweetwater—The City Commissioners plan an election to vote on bonds for a municipal electric light plant.

Utah, Salt Lake City—The B. P. O. E., No. 85, 59 South State St., plans to build a 6 story, 75 x 135 club house. About $400,000. Scott & Welch, Dooly Bldg., Archts. and Engrs.

Wash., Seattle—The University of Washington is having plans prepared for a 4 story, 75 x 225 ft. education hall. About $330,000. Bebb & Gould, Securities Bldg., Archts.

Cal., Los Angeles—St. John's Episcopal Church, Rev. G. Davidson, Pastor, is having plans prepared for a church including a steam heating system at Figeroa and Adams St. About $500,000. B. G. Goohue, 2 West 47th St., New York City, Archt. and Engr.

Cal., Pasadena—The Y. M. C. A., 721 South Hope St., is having preliminary plans prepared for a Y. M. C. A. building. About $350,000. J. Morgan, Merchants' Exchange Bldg., Archt.

B. C., Vancouver—The Coast Range Steel Co., 419 Metropolitan Bldg., incorporated by Mr. Landis and others, for $15,000,000, plans to build a steel works near here.

CONTRACTS AWARDED

Mass., Northampton — The Bd. of Pub. Wks. has awarded the contract for a 1 story pumping station, pipe line, etc., to D. A. Sullivan, Paradise Road, at $15,000.

N. Y., New York — The United Electric Light & Power Co., 130 East 15th St., has awarded the contract for a power plant at 134th St. and the East River to the U. S. Structural Co., 84 Bway., at $4,500,000. Noted Nov. 2.

Pa., Hog Island—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for a radio building here, to J. H. Pierce, 529 Law Bldg., Norfolk, Va., at $30,665.

Va., Cape Hatteras—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for a radio building here, to Donnell Zane Co., Inc., 350 Broad St., New York City, at $20,565.

W. Va., South Charleston—The Bureau of Yards and Docks, Wash., D. C., has awarded the contract for a distribution system here, to the General Electric Co., River Rd., Schenectady, N. Y., at $14,565.

N. C., Cape Lookout — The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for a radio building here, to Donnell Zane Co., Inc., 350 Broad St., New York City, at $13,865.

N. C., Gastonia—The Akray Mills has awarded the contract for a cotton mill including a steam heating system to the Turner Constr. Co., 244 Madison Ave., New York City, at $75,000.

N. C., Poyners Hill—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for a radio building here, to Donnell Zane Co., Inc., 350 Broad St., New Yok City, at $11,802.

O., Cleveland Heights (Warrensville P. O.)—The Bd. Educ. has awarded the contract for a 50 x 67 ft. power plant for school on Lee Road to P. Kirschner, 1008 Hippodrome Bldg., Cleveland, at $110,000. Two 220-hp. boilers will be installed in same. Noted Aug. 31.

O., Cleveland—The Glenville Hospital, 701 Parkwood Drive, has awarded the contract for a 2 story, 40 x 40 ft. addition to boiler and laundry building to Lehder Constr. Co., Engineers' Bldg., at $40,000. Noted Oct. 19.

O., East Cleveland (Cleveland P. O.) — The Natl. Lamp Wks. of the General Electric Co., Nela Park, has awarded the contract for two 250-hp. Sterling boilers to the Babcock-Wilcox Co., 1521 Guardian Bldg., Cleveland, at $25,000. Noted June 1.

Mich., Detroit—Frank & Seder, c/o Smith, Hinchman & Grylls, Archts., 710 Washington Arcade, has awarded the contract for an 8 story, 60 x 100 ft. mercantile building to Thompson-Starret Co., Lincoln Bldg. A central steam heating system will be installed in same.

Mich., River Rouge—The Bd. Educ., c/o A. R. Heuer, has awarded the contract for a high school on Dearborn Road to Bryant & Detwiler, 2336 Dime Bank Bldg., Detroit, at $1,000,000. Contract for steam heating and forced ventilating systems will be sublet. Noted March 9.

Ill., Area — The Catholic Archdiocese of Chicago has awarded the contract for several seminary buildings here, including a 1 and 2 story, 100 x 100 ft. power house, to the Thompson-Starrett Co., 175 West Jackson Bldv., Chicago. Est. cost $10,000,000.

Ill., Chicago — The Selwyn Corp., 229 West 42nd St., New York City, has awarded the contract for a theater and office building here, including a steam heating system to the Longacre Constr. Co., 127 North Dearborn St., at $1,000,000.

Iowa, Pocahontas—The County Aud. has awarded the contract for the installation of a steam heating and plumbing system and wiring in the proposed new court house to Carsten Bros., Ackley, at $36,000. Noted Nov. 16.

Mo., Maplewood (St. Louis P. O.)—The St. Louis Paper Can & Tube Co., 4400 North Union Ave., St. Louis, has awarded the contract for a 1 story, 200 x 540 ft. factory here, including a steam heating system to Widmer Eng. Co., Century Bldg., St. Louis, at $500,000.

Tex., Dallas—The Bd. Educ., Municipal Bldg., has awarded the contract for a 2 story high school at Haskell and McKinney Sts. to the American Constr. Co., 411 Gulf Bldg., Houston, at $648,000. A steam heating system will be installed in same.

Col., Ault—The Great Valleys Sugar Co., Central Savings Bank Bldg., Denver, has awarded the contract for a sugar factory here, to Schwarz Eng. Co., Mack Bldg., Denver, at $1,000,000.

Col., Denver — The School Bd. has awarded the contract for the installation of a heating and ventilating system in the Morey Junior High School to McCarty-Johnson Htg. & Engr. Co., 1440 Curtis St., at $90,075. Noted Oct. 5.

Ont., Pembroke — McGuire, Patterson & Palmer, Ltd., 343 West Dorchester St., Montreal, have awarded the contract for a match factory here, to Fraser, Brace & Co., 83 West Craig St., Montreal, at $5,000,000.